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Instruction Manual

980240

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MODEL 2820 DATA AMPLIFIER

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INSTRUCTION MANUAL

980240

MODEL 2820

DATA AMPLIFIER

DANA™

Dana Laboratories Incorporated
Irvine, California 92664

Telephone (714) 833-1234
Teletype 910-595-1136

August 1967
Revised March, 1972

Warranty

Within one year of purchase, Dana Laboratories will repair or replace, at our option, your instrument if in any way it is defective in material or workmanship. All parts and labor charges will be paid by Dana Laboratories. Just return the instrument to your nearest authorized Dana Service Center freight prepaid. We will return it to you freight prepaid.

DANA

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Dana Model 2820 (Figure 1.1) is a direct-coupled, active guard differential amplifier with low noise at gains up to 2500, (12500 on 2820 V3 option) wide bandwidth, a high level of common mode rejection, and fast settling time. Full scale output is ± 10 volts and 100 mA.

The Model 2820 provides complete isolation between the two input leads and output common. The input, output, and power supply contain RF interference suppression from external RF noise. No common mode return path is required to achieve a common mode rejection of 120 dB, dc to 60 Hz.

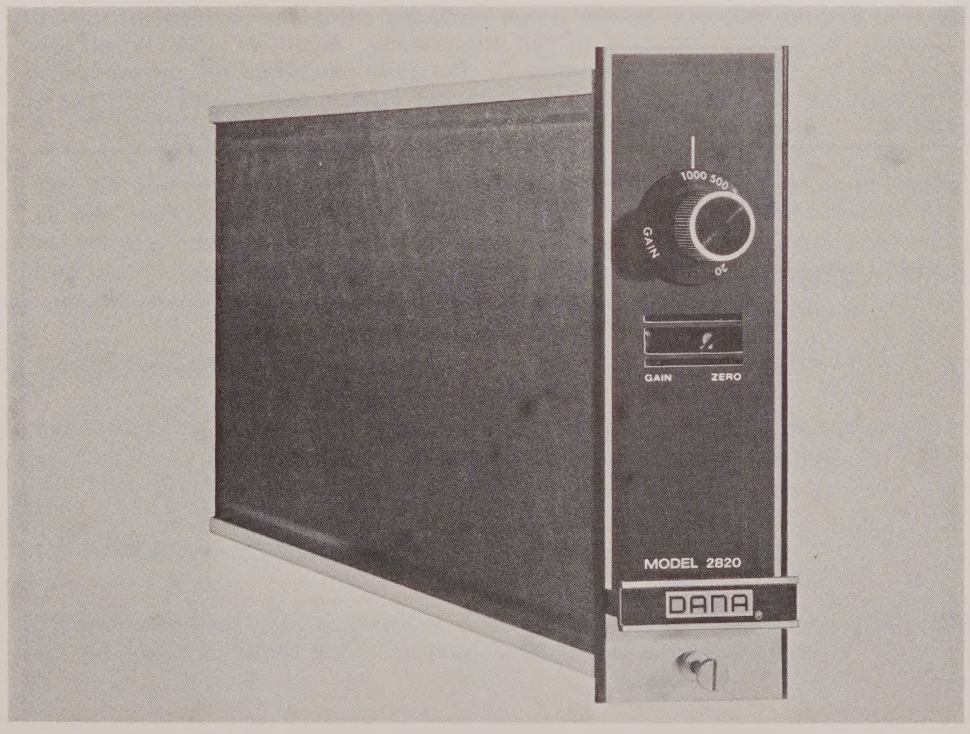


Figure 1.1 - Dana Model 2820 V1 Data Amplifier

Fail-safe circuits within the amplifier prevent damage from short circuits and from fault voltages up to 60 volts common mode (250 V_{cm} on low gain settings) and 30 volts normal mode. Overload recovery is 2 milliseconds from 500% overload of any duration. The step-function settling time is 500 microseconds.

System noise contributed by the amplifier circuitry is exceptionally low. The noise referred to the input at a gain of 1000 is less than 4 microvolts rms at full bandwidth and less than 1 microvolt, peak-to-peak, at a 10Hz bandwidth.

1.2 OPERATIONAL DESCRIPTION

A block diagram of the Model 2820 is shown in Figure 1.2. The Input Amplifier contains a Normal Mode Amplifier (NMA) and a Common Mode Amplifier (CMA). The NMA is a differential amplifier that amplifies the differential input voltage. Common mode voltage is effectively "cancelled out" in the NMA by feedback from the CMA. The CMA does this by sensing the common mode component of the signal in the first stage of the NMA and supplying an opposing voltage. The Output Amplifier consists of direct-coupled circuitry that determines the output characteristics of the amplifier. A portion of the output signal is applied back to the NMA through a precision attenuator network as negative feedback to define the closed-loop characteristics of the instrument. Amplifier gain is set by a voltage divider in the feedback network. Precision resistors are switched into this circuit by the GAIN switch. A detailed circuit description is given in Section 4.

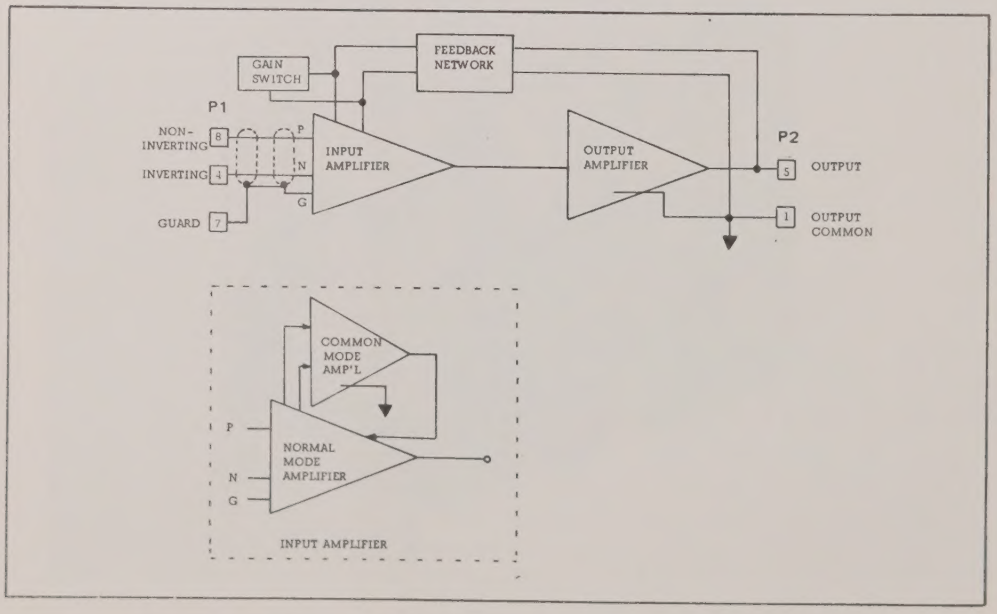


Figure 1.2 - Block Diagram, Model 2820

1.3 GAIN OPTIONS

Three gain options are available for various applications and must be specified when ordering the amplifier. They are designated as gain options V1, V2, and V3.

1.3.1 Option V1

The V1 option provides gain steps of 20, 50, 100, 200, 500, and 1000. A vernier multiplier extends each gain by a factor of 2.5:1. This feature allows continuous selection of gain values over the range of 20 to 2500. The V1 option is especially suited for use in applications where low-level, millivolt signals are to be amplified to voltage levels for accurate recording or measuring.

1.3.2 Option V2

The V2 option provides the same gain steps as the V1 option. Option V2, however, includes an X1/X.01 multiplier switch. This feature allows continuous selection of gain values over the range of 0.2 to 2500. The V2 option is especially suited for applications in which the input signal is already at a level of 1 volt or greater, or where the input may vary over a dynamic range from millivolts to full volts. Discriminators, potentiometers, and transformers are typical signal sources of this type and the amplifier serves as an isolation as well as scaling device.

1.3.3 Option V3

The V3 option provides gain steps of 100, 200,500, 1000, 2000, and 5000. A vernier multiplier extends each gain by a factor of 2.5:1. This feature allows continuous selection of gain values from 100 to 12,500. The V3 option is especially suited for applications that require an exceptionally high level of amplification such as a thermocouple temperature measuring system.

1.4 SPECIFICATIONS

Specifications are listed in Table 1.1. For definitions and a discussion of terms used refer to Appendix A, "Operating Characteristics and Definitions". Also, see "Low-Gain Considerations", paragraph 1.5.

1.5 LOW-GAIN CONSIDERATIONS

For easier evaluation of accuracy at low-gain operation, pertinent specifications are tabulated in Table 1.2 — in terms of percentage of full scale.

Table 1.1 - Specifications

DANA MODEL 2820 SPECIFICATIONS

All specifications apply for 0 to 350 ohm sources, in any unbalance.

Gain Option	Range	Steps	Accuracy	Resolution	Stability(at gain setting and constant temperature)	Temperature Coefficient
V1	20 to 2500 with 2.5:1 vernier	20,50,100,200, 500,1000	±0.1%	±0.01% (±0.1% worst case)	±0.01% (200 hours)	±0.005%/°C
V2	0.2 to 2500 with 2.5:1 vernier	0.2,0.5,1,2,5, 10,20,50,100, 200,500,1000	±0.1%	±0.01%(±0.1% worst case)	±0.01% (200 hours)	±0.005%/°C
V3	100 to 12,500 with 2.5:1 vernier	100,200,500, 1000,2000,5000	±0.1% K≤1000, ±0.15% K>1000	±0.01%(±0.1% worst case)	±0.01% (200 hours) K≤1000; ±0.01% x K/1000 (200 hours) K>1000	±0.005%/°C

	Gain (K) 20 to 1000	Gain (K) over 1000	Gain (K) below 20
OUTPUT (no damage for sustained short circuit)			
Full scale voltage	±10V	±10V	±10V
Voltage overrange, nominal	20%	20%	20%
Full scale load current	±100mA	±100mA	±100mA
Maximum short circuit current	±150mA	±150mA	±150mA
Impedance	0.1 ohm in series with 150uH	0.1 ohm in series with 150uH	0.1 ohm in series with 150uH
Capacitive load, without instability	0.33uF	0.33uF	0.33uF
Capability	Full scale voltage and current to 20kHz	Full scale voltage and current to 10kHz	Full scale voltage and current to 10kHz
FREQUENCY RESPONSE (at full output)			
Wideband dc to 100Hz	±0.01%	±0.02%	±0.01%
Minimum 3dB frequency	20kHz	10kHz	10kHz
Linearity (dc to 2kHz)	±0.01%	$\pm 0.005\% \times \frac{K}{100}$	±0.01%
COMMON MODE			
Rejection ratio dc to 60Hz	120dB, K = 1000 60dB + K in dB for all other gains	120dB, any gain	60dB, K = 10 40dB + K in dB for all other gains
Operating voltage dc to 60Hz	10V dc or peak ac	10V dc or peak ac	10V dc or peak ac
Fault voltage dc to 60Hz without damage	60V dc or peak ac	60V dc or peak ac	60V dc or peak ac
NOISE			
Full bandwidth	2uV rms RTI +2mV rms RTO	2uV rms RTI +2mV rms RTO	5mV rms RTO, any gain
10Hz	1mV peak to peak RTO, any gain	1mV peak to peak RTO, any gain	5mV peak to peak RTO, any gain
INPUT IMPEDANCE			
Normal mode	10Megohm, parallel with 0.002uF	10Megohm, parallel with 0.002uF	1Megohm, parallel with 0.002uF
ZERO STABILITY			
At constant temperature (after 30 minute warm-up)	±0.02% (200 hrs)	$\pm 0.02\% \times \frac{K}{1000}$ (200 hrs)	±0.1% (40 hours)
Temperature coefficient	(±0.001% RTO ±1uV RTI)/°C	(±0.001% RTO ±1uV RTI)/°C	(±0.001% RTO ±500uV RTI)/°C
STEP FUNCTION RESPONSE			
Settles to final value ±0.1% of full scale in	500 usec	1 msec	500 usec
Overload Recovery (to final value ±0.1% of full scale ±10uV RTI) 5 times full scale input, no damage for 30V dc or peak ac input on any gain	2 msec	2 msec	2 msec
TEMPERATURE RANGE (all options			
Operating	0°C to + 50°C		
Storage	-20°C to + 75°C		
POWER REQUIREMENT (all options)			
Domestic	105 to 125V rms, 50 to 400Hz, 6 watts		
Export Option 1	200 to 240V rms, 50 to 400Hz, 6 watts		
Export Option 2	215 to 265V rms, 50 to 400Hz, 6 watts		
Export Option 3	90 to 110V rms, 50 to 400Hz, 6 watts		

Table 1.2

Gain Setting	Zero Drift/Degree C as % of Full Scale	Error/Volt (Common Mode) as % of Full Scale
1000	0.011%	0.01%
500	0.006	0.01
200	0.003	0.01
100	0.003	0.01
50	0.002	0.01
20	0.001	0.01
10	0.051	0.1
5	0.026	0.1
2	0.021	0.1
1	0.011	0.1
0.5	0.006	0.1
0.2	0.003	0.1

1.6 AMPLIFIER ENCLOSURES

The Model 2808 Enclosure accommodates eight amplifiers. The enclosure is 7 inches in height with a depth of 22 inches and a width, including flanges, of 19 inches. The basic model is modified by a "dash" number which specifies the type of wiring interface.

The 2808 Enclosure accommodates all of the Dana Series 2800 Amplifiers. The amplifiers are interchangeable in the enclosure without alteration of the input and output cables.

The -1 Enclosure contains connectors to accommodate system wiring. Fusing and AC wiring are factory wired. A dimensional outline drawing (452402) of the 2808-1 Enclosure is included in Section 7, Drawings and Parts Lists.

The -2 Enclosure is fully wired. The inputs and outputs are accessible through connectors mounted on the rear panel. An outline drawing (452403) is included in Section 7, Drawings and Parts Lists.

The model 2802-2 enclosure accommodates two 2800 series amplifiers. All 2800 series amplifiers are interchangeable in the enclosure without alteration of the input and output cables.

The 2802-2 can be adapted for bench use or for rack mount use. Dimensions of the enclosure are, height 3.5 inches, depth 20 inches, width 17 inches. Inputs and outputs are accessible through connectors mounted on the rear panel. An outline drawing (402619 page 1 of 3) is included in Section 7, Drawings and Parts Lists.

1.7 AMPLIFIER ACCESSORIES

An Adapter Set Model 2801 (Dana part number 402468) and an Amplifier Support Bracket (Dana part number 452411) are used when the amplifier is operated on the bench. The Adapter Set (item 1 in Figure 1.3) contains input leads, output leads, and the power cord. The Amplifier Support Bracket (item 2 in Figure 1.3) mounts to the amplifier to support the amplifier in an upright position.

Figure 1.3 - Amplifier Accessories

SECTION 2

INSTALLATION AND INITIAL CHECKOUT

2.1 UNPACKING AND INSPECTION

The Dana Amplifier is shipped in a special reusable shipping package, designed to protect the instrument from excessive shock and vibration. Examine the package for signs of external damage before removing the unit. If external damage is present, notify the carrier before proceeding. Next, examine the outside of the amplifier for any evidence of damage due to excessive shock, vibration, water leakage, etc.

If the unit appears in perfect condition, proceed with the installation. However, if there is any apparent damage, communicate with the carrier for instructions.

2.2 POWER REQUIREMENTS

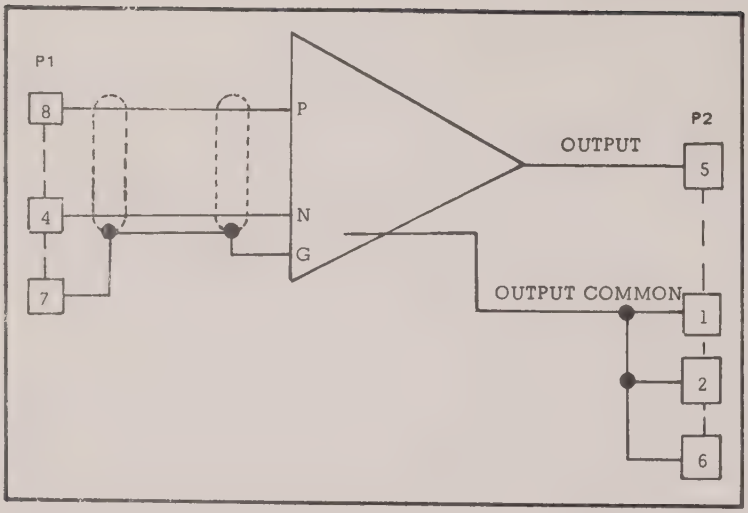
Dana Amplifiers, manufactured for domestic use, operate on 115 volts (±10 volts), 50 to 400 Hz. Units manufactured for export operate on 210 to 250 volts, 50 to 400 Hz. Power required is six watts.

NOTE

If the Amplifier has been stored for a prolonged period (5 or 6 months) without use, it is recommended that it be operated with a variable transformer, such as a Variac, at one-half line voltage for about two hours before gradually applying full power. This is done to "reform" the electrolytic capacitors in the amplifier and reduce the chance of capacitor failure.

2.3 INPUT/OUTPUT CONNECTIONS

Input and output connections to the amplifier are through eight pin connectors (P1 and P2) at the rear of the amplifier (see Figure 2.1). External connections are brought in through a mating connector. When the Dana enclosures are used, the mating connector for each amplifier is mounted on the inside back panel of the enclosure; each amplifier plugs into its corresponding connectors. When amplifiers are used singly, a single unit adapter set is normally used.



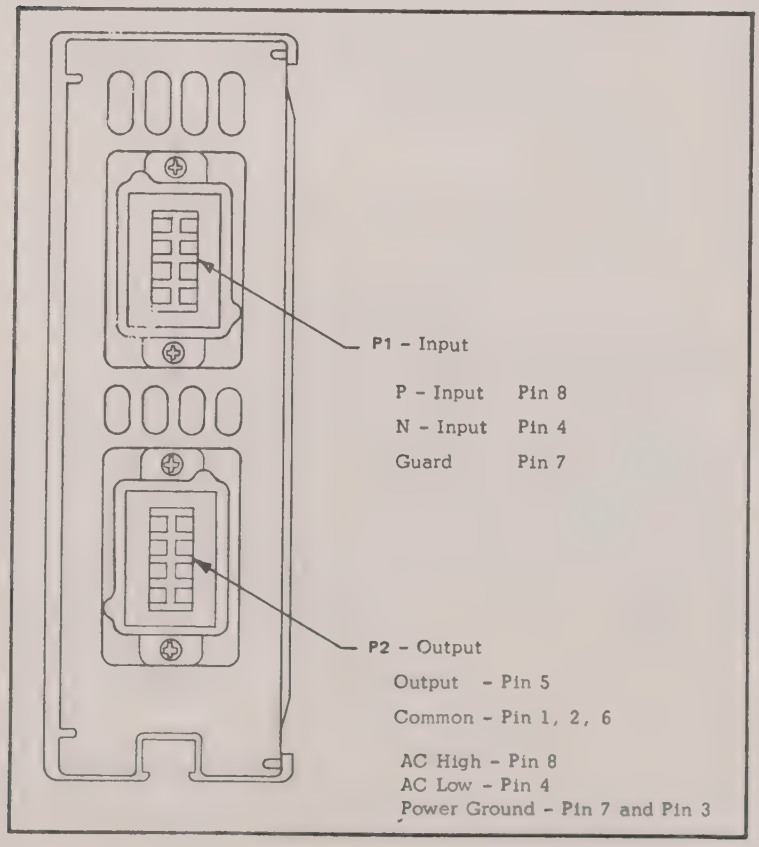

P1 - Input
P - Input Pin 8
N - Input Pin 4
Guard Pin 7
P2 - Output
Output - Pin 5
Common - Pin 1, 2, 6
AC High - Pin 8
AC Low - Pin 4
Power Ground - Pin 7 and Pin 3

Figure 2.1 - Input/Output Connections
Model 2820 Data Amplifier

When the 2808-1 Enclosure is used (see Figure 2.2), external connections are made directly to the solder side of the enclosure mounted connector for each amplifier. Access to connectors is gained by removing four screws holding the rear panel and allowing the top of the rear panel to drop away from the enclosure. External leads are routed through the grommet holes and soldered to the connectors.

In the 2808-2 Enclosure, conventional cable connectors are mounted on the rear panel. Connections are made by wiring to the mating connector. All pin connections are identified in Figure 2.2.

2.3.1 Power

When the Amplifier is to be operated within the 2808-1 or 2808-2 Enclosure, power is prewired and a three-wire line cord is supplied. When using the cord set, power and input/output connections are prewired. The power cord is connected to J1 of the cord set.

The ground wire of the power cord connects to the internal power supply shield of the amplifiers and the enclosure chassis.

2.3.2 Input/Output Signals

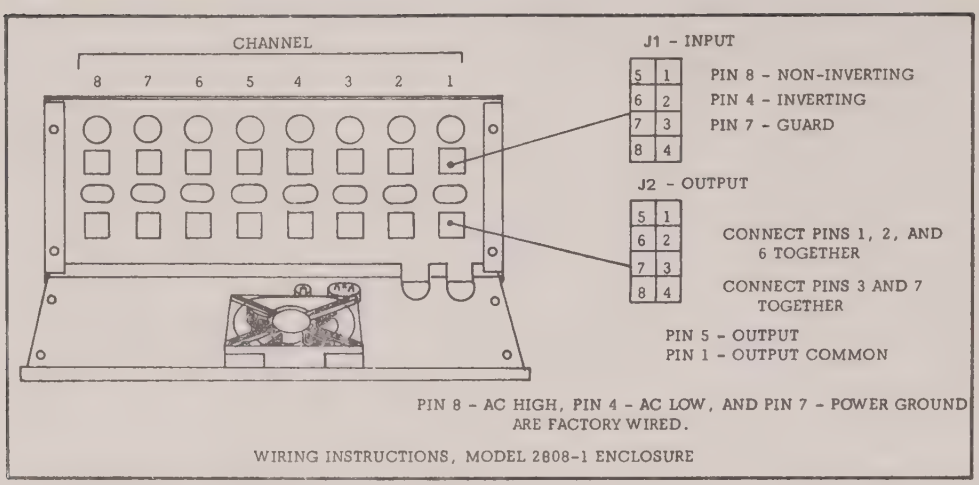
Input wiring configurations are extremely important in minimizing common mode voltages. The guard lead should be connected as close as possible to the signal source. Input and output connections are shown in Figure 2.2.

For permanent installations, low thermal solder (70% cadmium, 30% tin) should be used for all input connections to reduce thermocouple errors. For temporary or test setups, screw terminals or clips having low resistance may be used, taking suitable care to minimize thermal emf's (a few microvolts can be significant on high gain ranges).

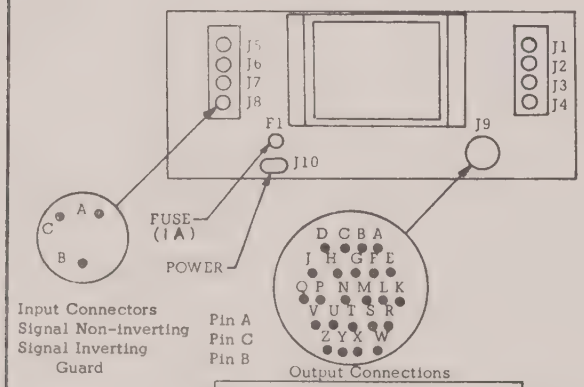
Since P and N inputs to the amplifier are symmetrical (approximately equal impedance to output common), either lead may be connected to either side of the signal source. For phasing purposes, if P is positive with respect to N, the output is positive with respect to output common.

Input leads should be two-conductor in an insulated shielded cable (Belden #8451-500, or equivalent). The shield must be soldered to the guard pin connection (pin 7 of P1 when a -1 Enclosure is used; pin B of the signal input connector for a -2 Enclosure). The unshielded portion of the leads must be kept as short as possible.

A single-conductor shielded cable is recommended for output leads. If two-conductor is used, connect one lead and shield together at either end or both ends. Solder the shield to Output Common (pin 1 of P2 for -1 enclosures; see Figure 2.2 for -2 enclosures). The enclosure chassis is connected to ground by the power cable. The lead from the output common terminal of the amplifier should be connected directly to the input common or ground of the output device.


CHANNEL
8 7 6 5 4 3 2 1
J1 - INPUT
5 1
6 2
7 3
8 4
PIN 8 - NON-INVERTING
PIN 4 - INVERTING
PIN 7 - GUARD
J2 - OUTPUT
5 1
6 2
7 3
8 4
CONNECT PINS 1, 2, AND 6 TOGETHER
CONNECT PINS 3 AND 7 TOGETHER
PIN 5 - OUTPUT
PIN 1 - OUTPUT COMMON
PIN 8 - AC HIGH, PIN 4 - AC LOW, AND PIN 7 - POWER GROUND ARE FACTORY WIRED.

WIRING INSTRUCTIONS, MODEL 2808-1 ENCLOSURE



CHANNEL	OUTPUT	OUTPUT COMMON
1	A	B
2	E	F
3	K	L
4	R	S
5	W	X
6	D	C
7	J	H
8	Q	P

CHASSIS GROUND PIN Z

NOTES: (1) Use shielded two conductor twisted pair cable for input leads. Shield is soldered to Guard Pin Connection.

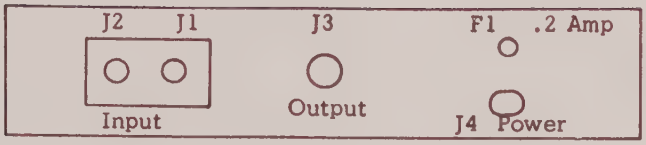
(2) Single conductor shielded wire is recommended for output leads. Solder shield to output common pin.

(3) Viewing enclosure from the front, amplifiers are numbered from left to right.

	Mating Connector & Clamps	Dana Part Number
INPUT	3106 A-10 SL-3S A105-A115	601561
(8 sets required)	3057-4A-A105 w/Bush	601474
OUTPUT	3106 A-24-28P-639	601563
(1 set required)	3057-16A-639 w/Bush	601564
AC POWER	Belden Power Cord #17256	600127
(1 set required)		

Wiring Instructions, Model 2808-2 Enclosure

Figure 2.2 - Enclosure Wiring



Input Connectors

Pin A	Signal Non-Inverting
Pin B	Guard
Pin C	Signal Inverting

Output Connector

Pin A	Channel 2 Output
Pin C	Output Common Channel 2
Pin D	Connector Shell
Pin E	Output Common Channel 1
Pin G	Channel 1 Output

Figure 2-3 2802-2 Enclosure Wiring

2.4 INITIAL CHECKOUT PROCEDURES

The amplifier is accurately adjusted and carefully inspected at the factory. The following tests check basic characteristics of the amplifier to verify proper operation upon delivery. The type of damage that can be expected in shipment tends to produce gross malfunctions rather than minor changes in sensitive characteristics. More complete and precise tests and calibration procedures are included in Section 5, "Calibration".

Only three items of test equipment are required to perform initial checkout of the amplifier:

- Audio Oscillator
- Voltage Divider/Attenuator
- Oscilloscope

Standard laboratory-type instruments from any manufacturer may be used.

2.4.1 Gain Checkout

1. Connect the common or ground terminals of each item of test equipment to a single point and to the amplifier output common (pin 1 of P2). Connect this point to ground. Make all measurements relative to this point (See Figure 2.4).

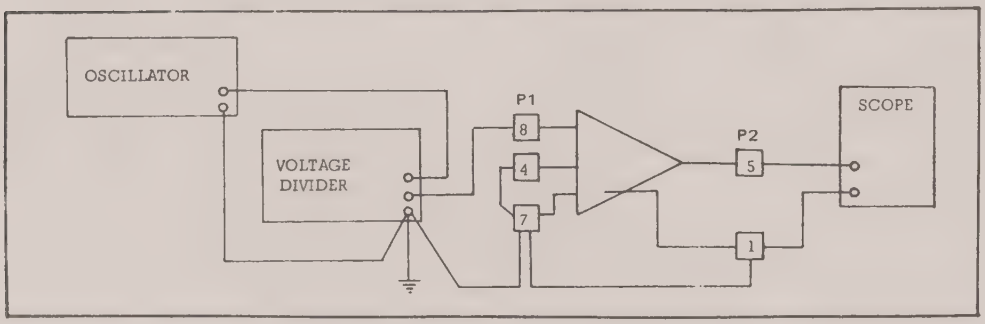


Figure 2.4 - Gain Test Setup

2. Set voltage divider to minimum output — zero, if possible.

3. Apply power to amplifier. Observe amplifier output or oscilloscope. It should be within a few millivolts of ground and change only very slightly as the amplifier GAIN switch is rotated.

4. Set the VERNIER gain adjustment fully counterclockwise

5. Set the GAIN selector switch at the highest gain position. If the amplifier is equipped with a Gain Multiplier switch (V2), set it to 1.0.

6. Remove scope lead from amplifier output and connect scope to the oscillator output. Adjust oscillator for 20 volts, peak-to-peak, at 100 Hz.

7. Set voltage divider to the reciprocal of the maximum gain setting, 1/K. (For example, at maximum gain of 1000, set divider to 0.001.)

8. Return the scope to the amplifier output, pin 5 of P2. The scope should now indicate approximately the same value, 20 volts peak-to-peak, observed at the oscillator output. (The term "approximately" is used because of the limited capability of an oscilloscope to compare two magnitudes accurately.)

9. Verify that there is no obvious noise or other unexplained distortions on the oscilloscope trace.

2.4.2 Frequency Response Checkout

1. Use test setup exactly as connected for Gain checkout. Set amplifier GAIN control at maximum; vernier adjustment to minimum. Connect scope to oscillator output; set oscillator frequency to 20 kHz. (Gains 20 to 1000; 10kHz for gains below 20 or above 1000).

2. Set oscillator output at 20 volts, peak-to-peak (on scope).

3. Remove scope lead from oscillator and connect to amplifier output pin 5 of P2. Adjust voltage divider for amplifier output amplitude equal to that observed in step 2.

4. Compare voltage divider setting with zero — or minimum output position. The difference should be no less than 3dB, or approximately 30%.

2.4.3 Common Mode Rejection

1. Short the amplifier input leads and the input guard lead (pins 8, 4, and 7 of P1). Connect all three to oscillator output.

2. Connect oscilloscope to amplifier output (pin 5 of P2).

3. Set oscillator output to 20 volts, peak-to-peak, at 60 Hz.

4. Set amplifier GAIN switch to 1000.

5. Observe amplifier output on scope. The output due to common mode is normally not detectable above the wideband noise of the amplifier. Common mode rejection can be calculated as follows:

$$CMR = \frac{20 \text{ Volts (P-P)} \times K}{\text{Output Voltage (P-P)}}$$

Common mode rejection may be measured more closely by following the procedures of paragraph 5.3.1, Section 5.

$$\text{CMR in dB} = 20 \text{ Log } \frac{20 \text{ volts (P-P) XK}}{\text{Output Voltage (P-)}}$$

$$\text{Example: CMR in dB} = 20 \text{ Log } \frac{20 \text{ Volts (P-P) XK (1000)}}{\text{Output Voltage 20 mV (P-P)}}$$

$$= \frac{20\text{V} \cdot 10^{3}}{20 \cdot 10^{-3}} = \frac{1\text{V } 10^{6}}{1} = 20 \text{ Log of } 1 \cdot 10^{6}$$

$$= \text{CMR 120 dB}$$

SECTION 3

OPERATION

3.1 MODES OF OPERATION

The Dana Amplifier can be used in any of the four operating modes illustrated below.

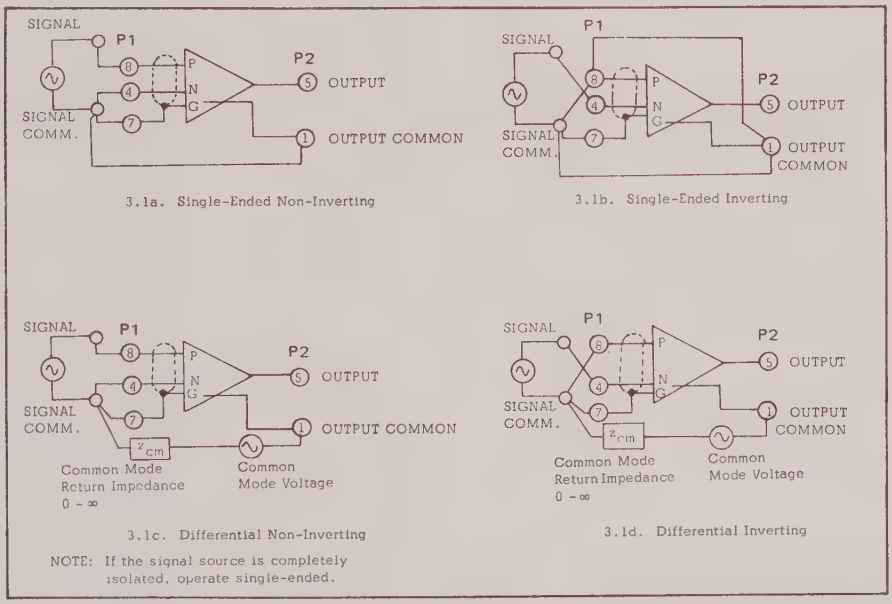


Figure 3.1 - Modes of Operation

3.2 CONTROLS

3.2.1 Gain Selector Switch

The GAIN switch is rotated to select the desired gain of the amplifier. The gains which can be selected vary with the options specified. Gain positions are tabulated below.

Options	Gain Switch Positions
V1 & V2	20, 50, 100, 200, 500, and 1000
V3	100, 200, 500, 1000, 2000, and 5000

3.2.2 Multiplier Switch (Option V2)

The Multiplier switch is mounted concentrically with the GAIN selector switch. It has two positions, X.01 and X1. In X.01 position, it reduces the gain selected by a factor of 100. For example, effective gains would be 0.2, 0.5, 1, 2, 5 and 10. In the X1 position, amplifier gain is exactly as inscribed on the switch.

3.3 OPERATIONAL ADJUSTMENTS

3.3.1 ZERO Adjustment

ZERO is a screwdriver adjustment on the front panel of the amplifier. It is used to set the output voltage to zero volts with no input. It is adjusted in the following manner:

1. Apply power to the amplifier and any adjoining heat-producing equipment and allow amplifier to stabilize (approximately 30 minutes),
2. Set GAIN selector switch to lowest gain position.
3. Return the input P(P1-8) and N(P1-4) leads to output common (P2-1).
4. Connect voltmeter or scope to amplifier output (P2-5) and common (P2-1).
5. Adjust ZERO for zero amplifier output. Counterclockwise rotation corrects for a positive output; clockwise rotation corrects for a negative output.

Model 2820-V3

3.3.2 GAIN Adjustment

This is a screwdriver adjustment which serves as a vernier adjustment of gain selected by the GAIN selector switch. The adjustment varies each gain position by a factor of 2.5:1 — providing continuous gain selection throughout all available ranges.

3.4 OPERATING PROCEDURES

After installation of the amplifier as described in Section 2, operation consists simply of selecting the appropriate gain. The amplifier is ready for use immediately with zero stabilility achieved within 30 minutes.

SECTION 4

CIRCUIT DESCRIPTION

4.1 INTRODUCTION

This section contains an electrical description of each circuit in the amplifier. A block diagram of the Model 2820 is shown in Figure 4.1.

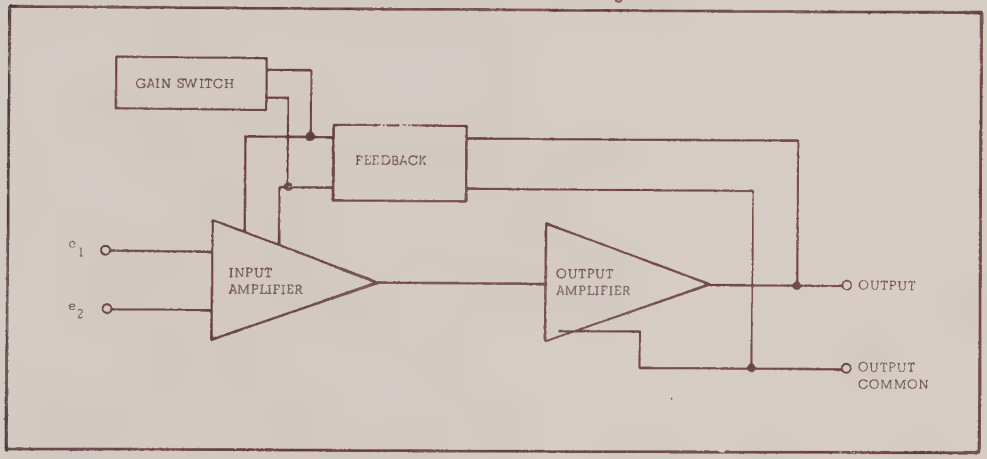


Figure 4.1 - Block Diagram

The forward loop consists of the Input Amplifier and the Output Amplifier. The loop is closed by the feedback network. The Input Amplifier amplifies the potential difference between the two inputs. When one input goes positive and the other input goes negative with respect to common, the output of the amplifier is proportional to the difference of the amplitudes. These signals are referred to as "normal mode signal" (also referred to as "difference" or differential signals). The potentials common to both inputs are referred to as "common mode signals" and are rejected by the amplifier. The normal mode signals and the common mode signals are defined below.

Normal Mode Signal $= e_1 - e_2$

Output (E_O) $= (e_1 - e_2)$ (Gain)

Common Mode Signal $= \dfrac{e_1 + e_2}{2}$

In single ended operation, a signal is applied to one input while the other input is common; therefore, the output is proportional to the amplitude of the one signal applied.

Figure 4.2 shows the amplifier responding to normal mode signals and rejecting the common mode signal (one-half) of the bridge supply voltage. In practical applications, there would be additional common mode potentials due to stray fields and other causes. These potentials represented by "e_x" are also rejected.

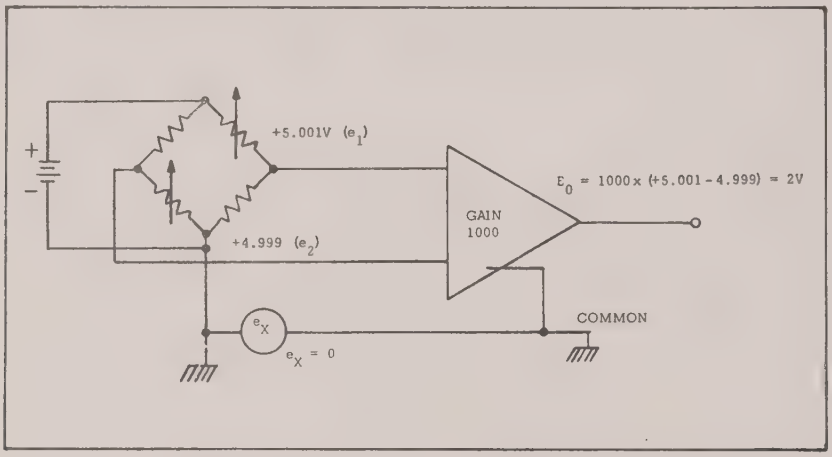


Figure 4.2 - Normal Mode and Common Mode Response

4.2 NORMAL MODE AMPLIFIER

Figure 4.3 shows a potentiometric amplifier. This type of amplifier is a potentiometric device, since the feedback achieves a high effective input impedance by the same principle as the common "null balance" approach to precision measurements. In both cases, the effective input impedance approaches infinity at null. In the potentiometric amplifier, impedance is limited by factors such as leakage and practical values of loop gain.

Examining the feedback system, it can be seen that the feedback is of proper phase to cancel the effect of the input signal; nowever, the cancellation leaves a small "error" signal of sufficient magnitude to support the 5-volt output. In the example, if the open loop gain (gain without feedback) of the circuit were 140 dB, the approximate residual error signal would be $5V/10^7$ or 0.5uV (e_e in the figure).

To achieve the desired gain stability and linearity, the open loop gain is considerably greater than the closed loop gain. By keeping this ratio sufficiently high, the "closed loop" or "net gain" is essentially determined by the feedback elements alone.

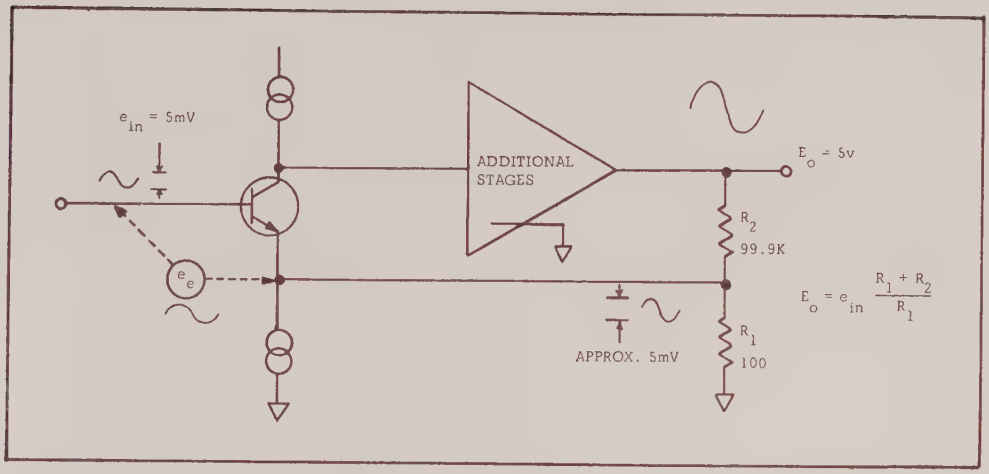


Figure 4.3 - Simplified Potentiometric Amplifier (Gain of 1000)

Figure 4.4 shows two potentiometric amplifiers connected in a differential configuration. One-half of the normal mode voltage ($e_{NM}/2$) appears at e_1 while the other one-half of the normal mode voltage appears at e_2. As in Figure 4.3, a 5 millivolt signal at each of e_1 and e_2 will be 5 volts output at each potentiometric amplifier. With the differential amplifier stage as shown in Figure 4.5, the outputs of the balanced differential stages are combined in the summing amplifier which transfers one directly and inverts the other. This is in keeping with the normal mode signal characteristics of $e_1 - e_2$. Signals of common polarity or phase will cancel at the summing stage, the degree of cancellation dependent on their relative magnitudes.

Input lines (e_1, e_2) are connected to the bases of a pair of matched silicon transistors (dual transistors in a single case) and circuit parameters are adjusted to obtain equal characteristics in each stage. A unique aspect of the circuit is the technique employed in controlling these parameters for stable operation over wide temperature ranges.

4.3 COMMON MODE AMPLIFIER

Although the Normal Mode Amplifier provides a degree of common mode rejection (CMR = 60 to 70 dB with balanced source), it is insufficient for high accuracy data systems. The primary deficiency of the circuit is the low impedance between the input lines and common - too low to materially reduce common mode currents. This deficiency is overcome by the use of a separate Common Mode Amplifier (CMA) which senses the common mode voltage at the input and forces the emitters of the "input pair" of the normal mode amplifier to the same potential (neglecting bias). This "bucking" voltage allows very little current to flow from either input to output common, increasing the intrinsic impedance to common.

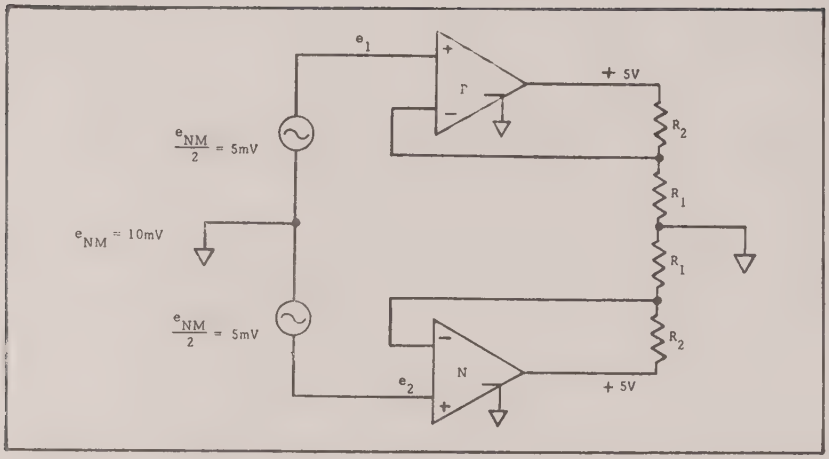


Figure 4.4 - Potentiometric Amplifiers in Differential Configuration

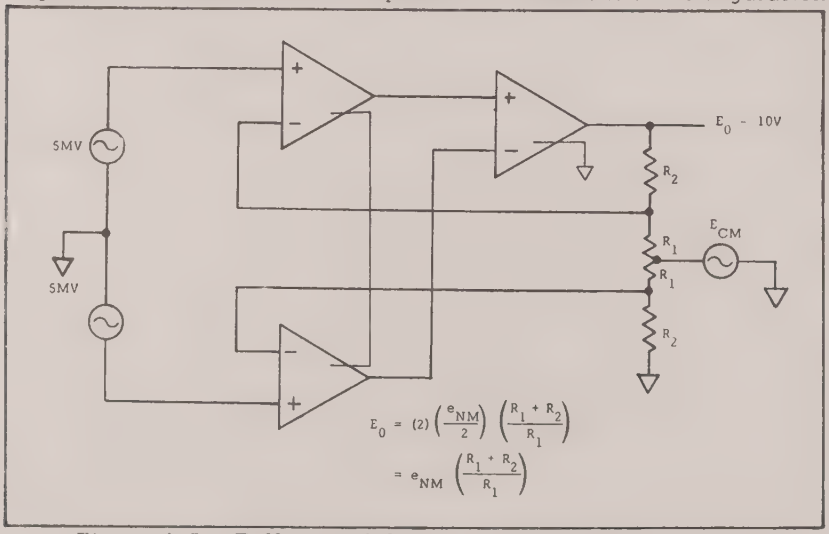


Figure 4.5 - Differential Stage for Summation of Inputs

Figure 4.6 shows the relationship of the normal mode amplifier and the common mode amplifier. The output of the common mode amplifier (E_{CM}) is connected to the junction of the R_1 resistors.

The voltages, e_1 and e_2, appear at the voltage divider as shown in Figure 4.6. The "bucking" voltage is supplied by the common mode amplifier.

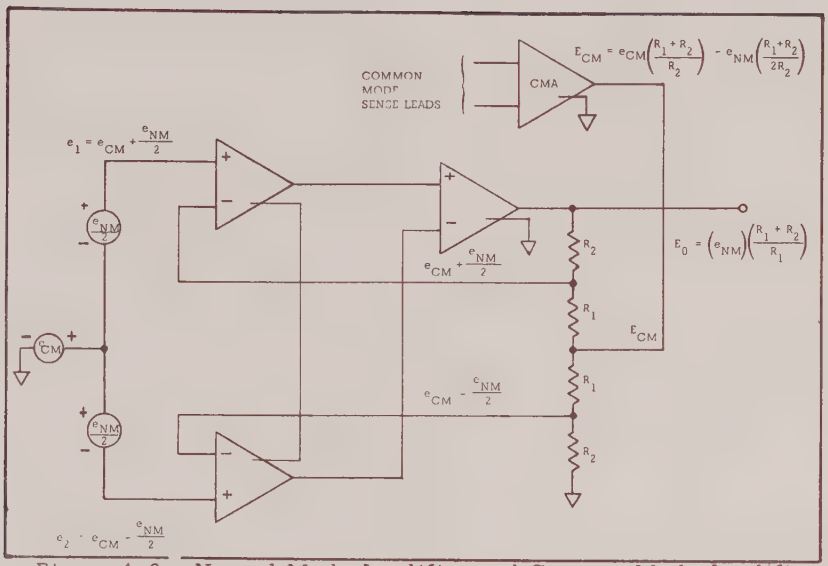


Figure 4.6 - Normal Mode Amplifier and Common Mode Amplifier

Consider the upper-half of the voltage divider and the lower-half of the voltage divider as shown in Figure 4.7. The upper-half of the voltage divider is bounded by the two voltages E_O and E_{CM}. The voltage at E_{01} is equal to

$$E_{01} = E_O - \left(E_O - E_{CM}\right)\left(\frac{R_2}{R_2 + R_1}\right)$$

and is the "bucking" voltage to effectively cancel $e_{CM} + \frac{e_{NM}}{2}$.

The lower-half of the voltage divider is bounded by E_{CM} and common. The voltage at E_{02} is equal to

$$E_{02} = E_{CM}\left(\frac{R_2}{R_1 + R_2}\right)$$

and is the "bucking" voltage to effectively cancel

$$e_{CM} - \frac{e_{NM}}{2} .$$

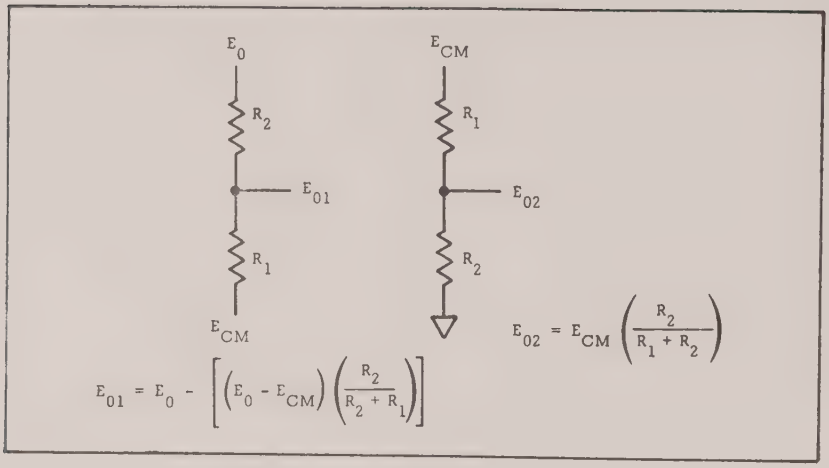


Figure 4.7 - Voltage Dividers

The common mode voltage (E_{CM}) from the common mode amplifier required to satisfy the equations is

$$E_{CM} = e_{CM}\left(\frac{R_1 + R_2}{R_2}\right) - e_{NM}\left(\frac{R_1 + R_2}{2R_2}\right)$$

The gain of the normal mode amplifier is set by inserting a resistor R_X as shown in Figure 4.8. Resistor R_X does not influence the value of E_{CM} and may be varied without interfering with the common mode compensation.

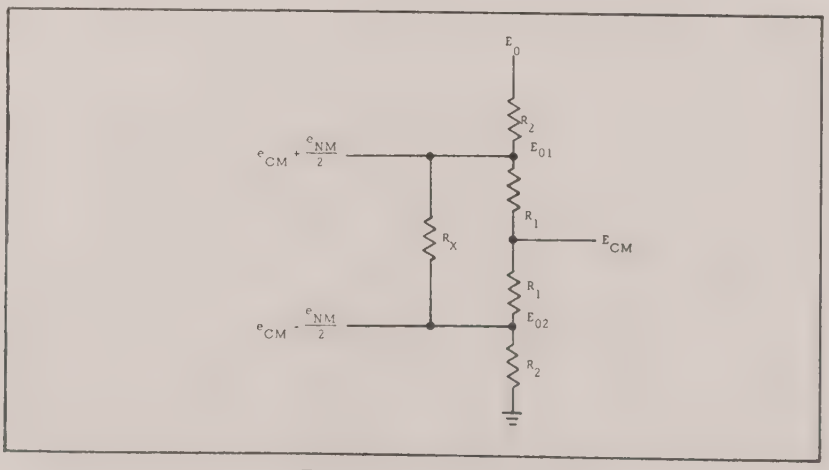


Figure 4.8 - Gain Set

4.4 INPUT AMPLIFIER

The Input Amplifier can now be shown as in Figure 4.9a. Differential input signals cause out-of-phase signals to be developed across the input pair's respective collector resistors. Under these conditions, the drop across the collector summing resistor (R36 in Figure 4.9a) remains constant; however, a voltage source common to both input lines (e_{CM}) causes in-phase collector current variations which add through R36 and produce a signal proportional to the common mode potential, providing an input to the CMA. As illustrated in Figure 4.9a, the CMA couples a feedback signal to the emitters of the input pair through R42 and R44. This signal is of the proper phase to cancel the effect of the input potential and maintain the sum of the two collector currents constant. Cancellation is complete except for a small residual error voltage necessary to maintain the output of the CMA very near the common mode potential (ignoring feedback insertion loss).

For convenience, the Common Mode Amplifier has been described as if it were a single-ended device referenced to ground. However, the CMA is a differential amplifier much like the Normal Mode Amplifier and, as such, responds to the difference between its input terminals. In the actual circuit, one of the CMA input terminals is connected to the lower side of the input stage collector summing resistor and the other to a passive divider connected between the input pair emitters and the top of the collector summing resistor (Figure 4.9a).

If this circuit is closely examined, it can be seen that the various circuit elements form a simple bridge. This identity is established in Figure 4.9b. In operation, the application of a common potential to the input transistors tends to unbalance the bridge by changing the conductance of the input pair. This effect is opposed by driving the lower end of the bridge (or the emitters of the input pair) with the output of the CMA. This feedback effectively cancels the change in conductance and restores the bridge to balance.

As previously stated, the parameters of the input stage are carefully adjusted for nearly identical characteristics. Once established, they cannot be allowed to change when the circuit is subjected to common mode potentials. From Figure 4.9 it can be seen that the entire input circuit is floating between two constant current generators. Since it has been established that the active elements in the bridge circuit (transistors) are continuously balanced against passive elements (R36, R39, R50, R41), it becomes apparent that the constant current sources will also serve to maintain constant voltage conditions across the bridge (constant I x constant R = constant E). This means that, as the lower part of the bridge is driven up and down synchronously with the common mode potentials, the voltage at the top of the bridge varies with the same relative magnitude. This "bootstrapping" effect raises the intrinsic common mode rejection of the input pair to the high values required for high accuracy systems.

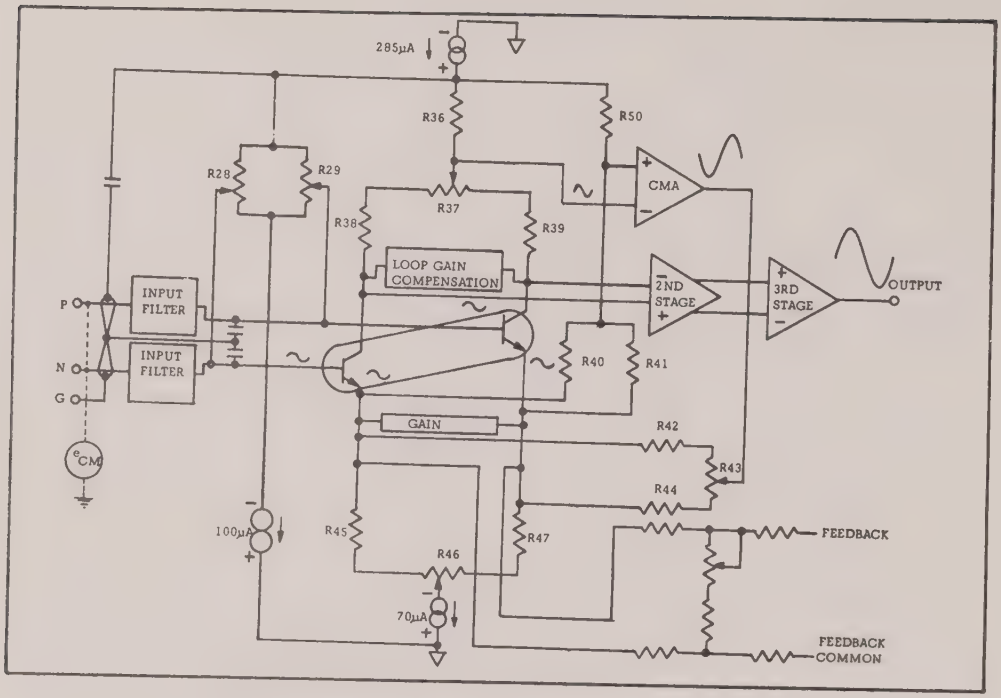


Figure 4.9a - Input Amplifier

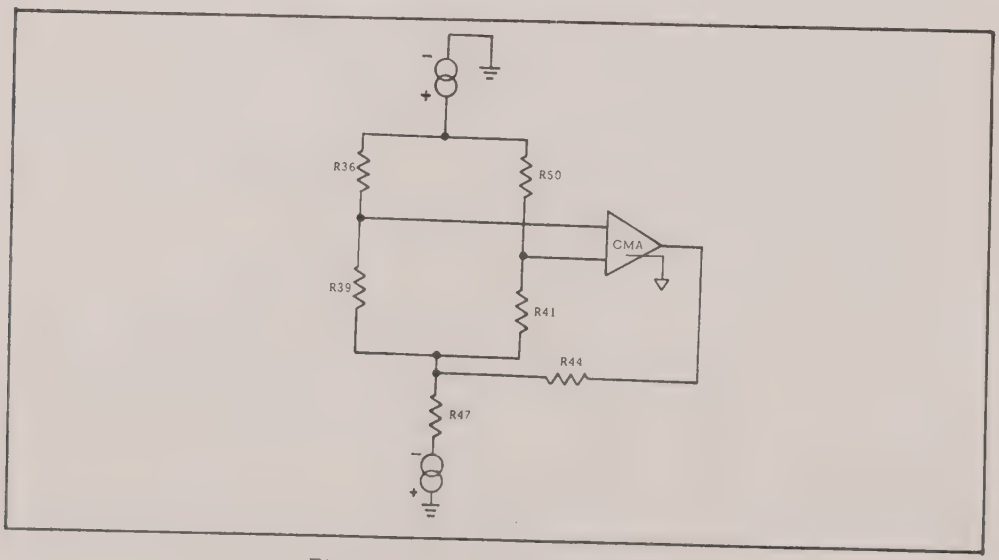


Figure 4.9b - Equivalent Bridge

Potentiometers R28 and R29 are the N-input and P-input offset-current zero adjustments to minimize the current flow-through the input terminals.

The gain and loop-gain compensation blocks shown in Figure 4.9 are networks selected from the front panel GAIN select switch.

4.5 OUTPUT AMPLIFIER

The Output Amplifier (Figure 4.10) consists of a voltage-to-current converter stage followed by a single ended operational amplifier. The single ended amplifier is a complementary symmetry class AB power amplifier with negative feedback.

A separate power supply provides a positive voltage and a negative voltage capable of delivering up to 100 milliamperes to the load. The power supply is shown as batteries in Figure 4.11.

The current supplies are controlled by common emitter drivers and are driven with respect to common in accordance with the input signal. Transistor Q20 controls the positive current through the load. As the positive current increases through the load, the output voltage at the common connection node of the current supplies goes negative. As the negative current increases through the load (controlled by transistor Q22), the output voltage goes positive.

The negative current limit is determined by adjusting R91 (10 ohm potentiometer), the positive current limit is determined by adjusting R92 (10 ohm potentiometer). The current adjustment for each potentiometer is approximately 95-150 milliamperes. Diode clamps, CR17 and CR18, will conduct when the voltage across either the emitter resistor of the output driver (Q20) or the emitter resistor of the current limiter (Q21) reaches +0.6 volt. Diode clamps, CR19 and CR20, will conduct when the voltage across either the emitter resistor of the output driver (Q22) or the emitter resistor of the current limiter (Q23) reaches -0.6 volt.

The short-circuit current limit of the Output Amplifier is approximately 150 milliamperes. The current limit for a 100 ohm load is approximately 120 milliamperes.

Transistor Q17 (see schematic drawing of Output Amplifier in Section 7) is a constant current bias generator (one milliampere).

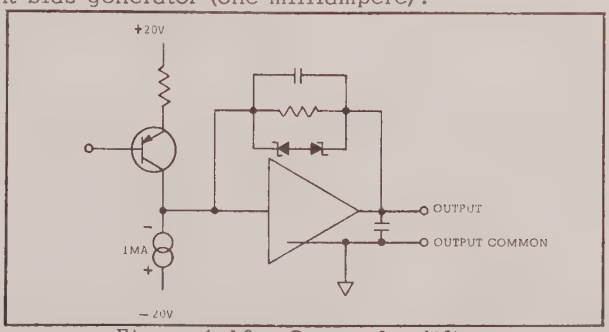


Figure 4.10 - Output Amplifier

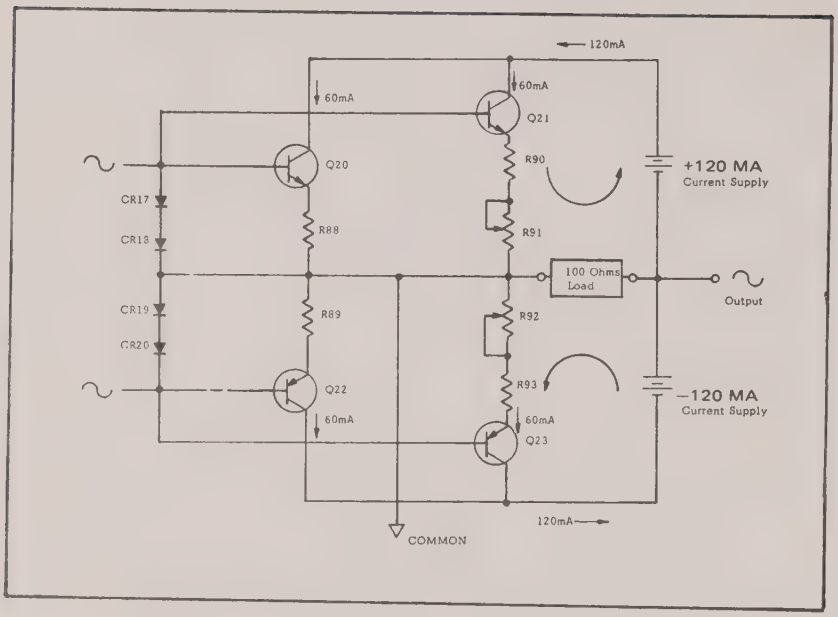


Figure 4.11 - Output Drivers and Current Limiters

4.6 FEEDBACK CIRCUIT

The differential input of the amplifier requires a feedback network slightly more complex than the simple divider that was shown in Figure 4.3. To illustrate, consider the case where one input is connected to a positive signal and the other to a negative signal. It would appear that the proper bipolar feedback for both inputs could not be derived from a single output terminal; however, this is not the case.

Figure 4.12 shows the equivalent feedback network of the amplifier. For the purpose of the initial discussion, assume no connection between points A and B, and that the amplifier has somehow arrived at the proper ten-volt output for a ten-millivolt input (gain of 1000). It can be seen that the voltage difference between the two feedback lines is the required 10 millivolts; however, both lines are approximately +5 volts above common. This is obviously intolerable and the circuit will not function until a connection is made between points A and B. It should be emphasized that the +5 volts is common to both input transistors and would tend to unbalance the common mode bridge just as an external common mode potential would do. The only difference in the two situations is the fact that the "feedback" common mode voltage is internally generated and tends to drive the input emitters in lieu of the bases. The latter results in one less phase inversion for internally generated common mode signals, producing an output from the CMA fo the opposite output which goes negative until the feedback lines become approximately +5 millivolts and -5 millivolts with respect to common.

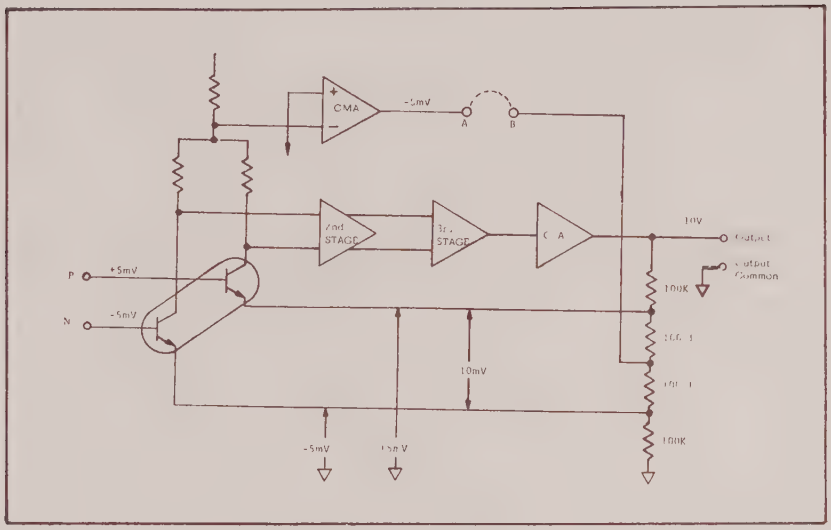


Figure 4.12 - Equivalent Feedback Network for Gain of 1000

It can now be seen that the CMA will not tolerate the bridge to be unbalanced at any time, whether the common mode potential is introduced internally or externally. More specifically, the collector currents are never permitted to shift in the same direction but can only vary by equal and opposite amounts in response to differential input signals. This fact holds true regardless of the symmetry of the input signals. For example, consider the situation where one input is tied to common and the other is driven with a 10 millivolt AC signal. The CMA assumes the proper signal level so that equal and opposite error signals exist between the base and emitter of each input transistor. The final quiescent conditions are shown in Figure 4.13.

4.7 ADDITIONAL CIRCUIT DETAILS

For ease of explanation, several circuit details were intentionally overlooked. Specifically, the diagrams used to illustrate certain fundamental points inferred a quiescent voltage level of zero at several points that are normally several volts positive or negative with respect to ground. Circuit operation as described is fundamentally accurate except that signal levels are relative to the initial conditions. The static bias condition of the input pair is of particular interest since it is related to input current uncertainty. These stages are initially forward biased and, though the base idling currents are quite low, they would develop an offset voltage if allowed to flow through the external signal source resistance.

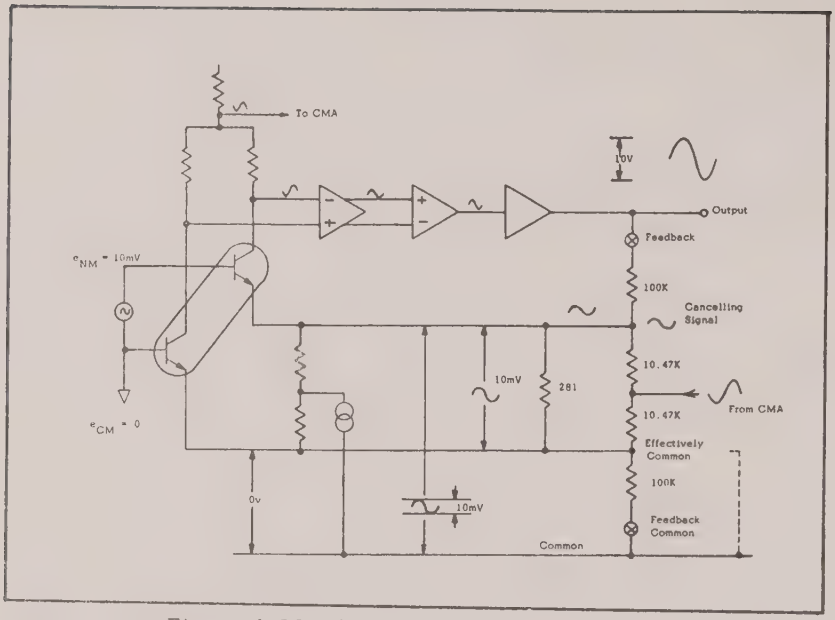


Figure 4.13 - Forced Internal Symmetry

To minimize this effect, each input line is connected to a source that shunts this current to the amplifier's internal supplies. An adjustment is provided for each input line, permitting the input current to be periodically rezeroed in the field (R28, R29 in Figure 4.9). To prevent common mode loading, these sources are floated between a constant current generator and the top of the common mode bridge. Since both input leads and the collector supply move together with the common mode potential, the current through the base resistors remains very nearly constant. This infers that the impedance to common potentials is a large magnification of the apparent 5 megohms in each base lead (on the order of 1000 megohms); and also points out that the quiescent base current is virtually undisturbed by common mode potentials.

Another important point is the relationship between the magnitude of the common mode potential and the voltage level at the output of the CMA. If the source of common mode is external, the output of the CMA is 10% greater than the applied voltage; if the source is internal (one-half of the output signal), the output of the CMA is $-E_{out}/20$. This relationship is solely determined by the ratio of the respective feedback resistors.

SECTION 5

CALIBRATION

5.1 RECOMMENDED TEST EQUIPMENT

- OSCILLOSCOPE: X-Y inputs; bandpass, DC-500 kHz; calibrated deflection factors of one millivolt to 20 volts per centimeter accurate within 3%; input impedance, one megohm paralleled by less than 50 picofarad.

- OSCILLATOR: Frequency range, 5 Hz - 500 kHz; accuracy, ±2%; frequency response, ±1 dB; adjustable output voltage, 160 milliwatts (10 volts) into 600 ohms rated load, 20 volts open circuit.

- VACUUM TUBE VOLTMETER: Voltage range, 0.1 millivolt to 300 volts; dB range, -72 to +52 dB; frequency range, 10 Hz to 1 MHz accurate within ±2% (50 Hz - 500 kHz); input impedance, 10 megohms paralleled by less than 50 picofarad.

- ATTENUATOR: Attenuation to 120 dB in 1dB steps; DC to 1 MHz accurate within ±1 dB; power capacity, 5 watts.

- DC MILLIVOLTMETER (optional)

- Dana Model 2195 Test Panel (optional) or Adapter Set 2801 (P/N402468).

The Dana Model 2195 Amplifier Test Panel provides a convenient means of testing and calibrating Dana amplifiers. The panel requires that only the amplifier input, output, and power be connected to the panel with no further reconnections required. All input and output configurations necessary to calibrate or test the amplifier are set up by switches and controls mounted on the panel. The panel is shown in Figure 5.1.

5.2 LISSAJOUS FIGURES FOR COMMON MODE ADJUSTMENTS

The output null of the amplifier is checked with the Lissajous figures as shown in Figure 5.2. The adjustments for the quadrature error and amplitude error are mentioned in paragraph 5.3.1. Figure 5.2a shows the amplifier output at null for maximum common mode rejection.

Figure 5.1 - Model 2195 Amplifier Test Panel

The V1 and V3 gain options quadrature error and amplitude error are adjusted by adjusting the following components:

Capacitor C15	- quadrature error	Refer to Figure 5.2b
Potentiometer R43	- amplitude error	Refer to Figure 5.2c

The V2 option has the above adjustments when the Multiplier switch is in the X1 position. Another set of adjustments calibrates the quadrature and amplitude error for the X.01 Multiplier switch position. These adjustments are:

Capacitor C5	- quadrature error	Refer to Figure 5.2b
Potentiometer R10	- amplitude error	Refer to Figure 5.2c

The procedures for the above adjustments are detailed in paragraph 5.3.4.

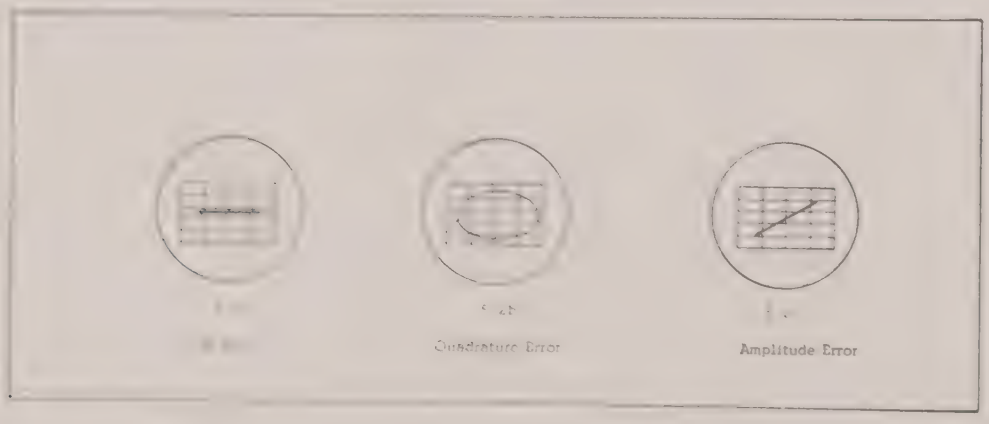


Figure 5.2 - Lissajous Figures

5.3 CALIBRATION PROCEDURES

In addition to the following calibration procedures, certain performance characteristics should be checked periodically and internal adjustments made as required. These measurements are described in section 5.4. The procedure below should be performed in the order listed.

All adjustments are easily accessible through the side of the amplifier. Physical location of the adjustable components is shown in Figure 5.3.

> CAUTION
>
> Common mode potentials appear between the guard box and chassis; therefore, an insulated screwdriver or adjustment tool (J.F.D Adjustment Tool 5284) should be used to make the calibration adjustments of the input amplifier.

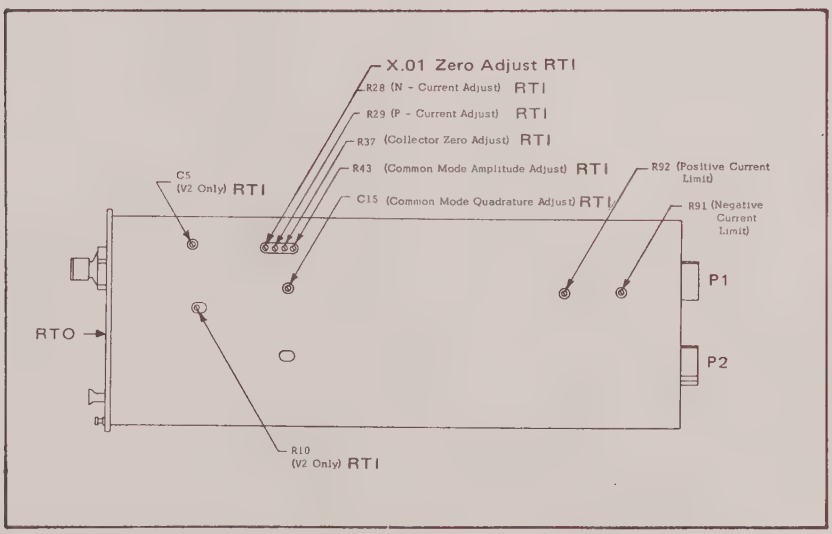

X.01 Zero Adjust RTI
R28 (N - Current Adjust) RTI
R29 (P - Current Adjust) RTI
R37 (Collector Zero Adjust) RTI
R43 (Common Mode Amplitude Adjust) RTI
C15 (Common Mode Quadrature Adjust) RTI
C5 (V2 Only) RTI
R92 (Positive Current Limit)
R91 (Negative Current Limit)
P1
P2
RTO
R10 (V2 Only) RTI

Figure 5.3 - Amplifier Adjustments, Physical Location

5.3.1 Common Mode Adjustment

Common mode adjustment procedures are as follows:

(1) For V1 attenuator option:

(a) Connect inputs P(P1-8), N(P1-4), and guard (P1-7) to the high side of a signal generator, returning the low side to output common (P2-1).

(b) Connect the signal generator to the X-axis (horizontal) of an oscilloscope with the X-axis sensitivity set to 5 V/cm.

(c) Connect the amplifiers output (P2-5) to the Y-axis (vertical) of the oscilloscope through a single pole, low pass filter consisting of a 16K resistor and a 0.01 microfarad capacitor. Set the sensitivity of the Y-axis to 10 mV/cm. (See figure 5.4).

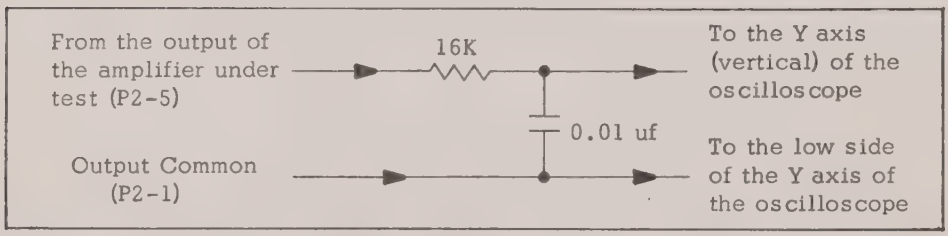

From the output of the amplifier under test (P2-5)
16K
To the Y axis (vertical) of the oscilloscope
0.01 uf
Output Common (P2-1)
To the low side of the Y axis of the oscilloscope

Figure 5.4 - Single-pole low pass filter

(d) Place the gain switch (S1) in the 1000 position, and the variband switch (S2) in the wideband position.

(e) Set the signal generator to 20 volts (P-P) at 60 Hz.

(f) Adjust the amplitude error potentiometer (R43) for minimum amplitude error as shown in figure 5.2c.

(g) Adjust the quadrature error trimmer (C15) for minimum quadrature error as shown in figure 5.2b.

(h) Adjust both R43 and C15 for a straight line as shown in figure 5.2a.

(2) For V2 attenuator option:

(a) Complete steps 5.3.1(1) (a) through (h) before continuing the Common Mode Adjustment for V2 attenuator option.

(b) Place the multiplier switch to the X.01 position.

(c) Adjust the amplitude error potentiometer (R10) for minimum amplitude error as shown in figure 5.2c.

(d) Adjust the quadrature error trimmer (C5) for minimum quadrature error as shown in figure 5.2b.

(e) Adjust both (R10) and (C5) for as near as possible a straight line as shown in figure 5.2a.

(3) For V3 attenuator option:

(a) For V3 attenuator option, complete steps, 5.3.1 (a) through (h). Be sure the gain switch (S1) is in the 1000 position, and not the 5000 position. All common mode adjustments and measurements are performed in the gain of 1000.

5.3.2 Collector Zero Adjustment (RTI)

In addition to the operational zero (RTO) adjustment on the front panel, the amplifier is equipped with an internal RTI collector zero adjustment (R37). Procedure for making the adjustment is as follows:

(a) Connect the amplifier inputs P(P1-8), N(P1-4), and guard (P1-7) to output common (P2-1).

(b) Connect an oscilloscope or millivoltmeter to output (P2-5) and common (P2-1).

(c) Set the amplifier gain switch to the gain position (20 for V1, V2 options; 100 for V3 option); set (V2 options only) the multiplier in the X1 position.

(d) Adjust the front panel RTO zero adjustment (R46) for minimum reading on the oscilloscope or millivoltmeter. Record any residual offset.

(e) Set the amplifier gain switch to the 1000 position for gain options V1, V2, and V3 option.

(f) Adjust the internal RTI collector zero adjustment (R37) for the same offset recorded in step (d).

(g) Repeat steps (d), (e) and (f) until the output remains the same on both the higher and the lowest gain positions.

(h) Set the multiplier switch (V2 options only) in the X.01 position.

(i) Set the gain switch to the 1000 position.

(j) Adjust the "N" current adjustment (R28) for the same offset recorded in step (d). The "N" current adjustment (R28) also adjusts the X01 multiplier RTI zero adjust.

5.3.3 Input Current Adjustment

This adjustment minimizes current flow through the input terminals. For most accurate adjustment, the following procedures should be performed after the collector zero adjustment.

(a) Set the amplifier gain switch to the gain of 1000 for V1, V2, and V3 options. Set the multiplier switch (V2 option only) in the X1 position.

(b) Connect a 1K ohm resistor to the P input lead P(P1-8). Connect another 1K ohm resistor to the N input lead N(P1-4). Connect the two 1K ohm resistors and guard (P1-7) to output common (P2-1). (See Figure 5.5)

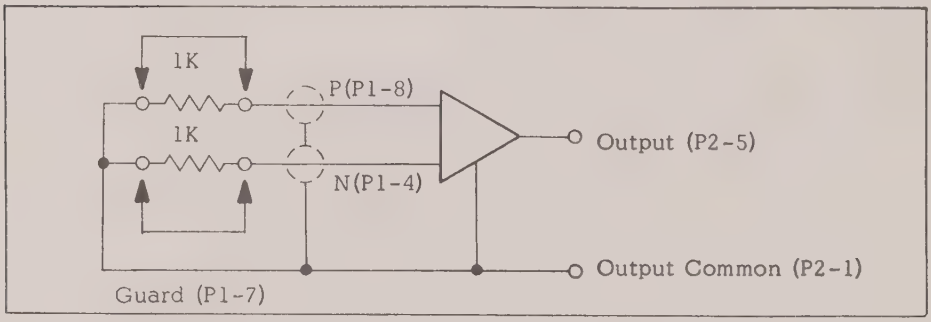


Figure 5.5 - Input Lead Connections

(c) Connect the oscilloscope to output (P2-5) and common (P2-1). Set the vertical deflection to 5 mV/cm.

(d) Short out the 1K ohm resistors in step 5.3.3b. Record the output offset as indicated by the oscilloscope. (See figure 5.5)

(e) Remove the short across the 1K ohm resistor in series with the N lead (P1-4). Adjust R28, the N current control for the same offset recorded in step 5.3.3d. Short out the 1K ohm resistor on the N lead.

(f) Adjust R37 RTI collector zero for the same offset as step 5.3.3d.

(g) Remove the short across the 1K ohm resistor in series with the P lead (P1-8). Adjust R29 P-current adjust; for the same offset as in step 5.3.3d. Short out the 1K ohm resistor on the N lead.

(h) Repeat step 5.3.3f.

(i) Repeat steps (e), (f) and (g) until there is no offset between the P or N leads with or without the 1K ohm resistors in series. All three voltages should be the same offset within 1 mv of each other.

(j) Set the multiplier switch (V2 only) to the X01 position. Adjust R28 N-current adjustment to the same offset as in step 5.3.3d.

5.3.4 Output Zero Adjustment

This adjustment sets the zero of the Output Amplifier by means of the ZERO adjustment on the front panel.

1. Connect input terminals N(P1-4) and P(P1-8) to output common (P2-1). Connect this point to ground.

2. Connect an oscilloscope across the output (P2-5) and common (P2-1).

3. Vary the ZERO adjustment (on front panel) for minimum reading on oscilloscope. Note this voltage for further reference. (This voltage represents residual offset).

5.3.5 Output Current Limit Adjustment

Although the output short circuit current is set at Dana for ± 150 ma, it may be desirable to limit the output current to a lesser value to afford the recording device protection. Potentiometers R91, 92, located on the printed circuit board, vary the output short circuit current from 60 ma to 150 ma. A voltage limit at the output of ± 13V DC or peak AC provides an additional degree of protection to the recording device.

To set the output current for 100 milliamperes, follow the steps below:

(1) Connect a 10 volt power supply, a 10 ohm 1/2 watt load resistor, and a DC voltmeter as shown in Figure 5.6. Connect battery as in position "A".

(2) Adjust R92 until the voltmeter reads 1.0 volts ± 10%.

(3) Connect the battery as in position "B".

(4) Adjust R91 until the voltmeter reads 1.0 volts ± 10%.

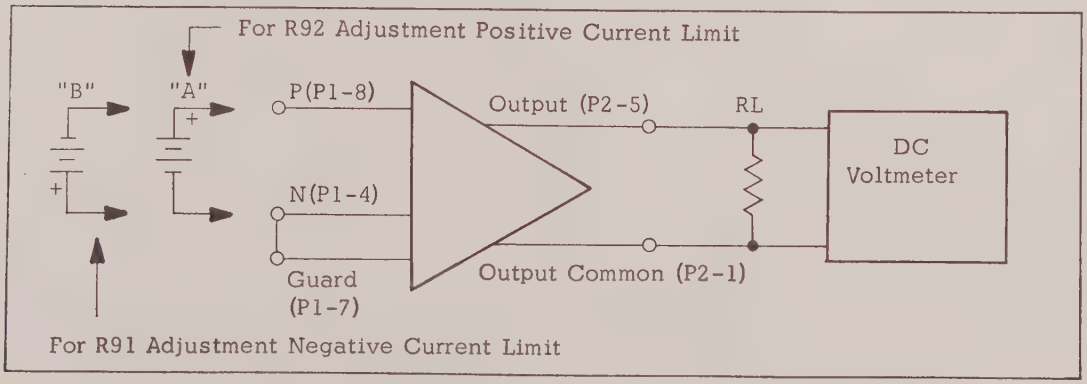


Figure 5.6 - Test Setup for Current Limits

5.4 TESTS OF AMPLIFIER CHARACTERISTICS

The following measurements check basic amplifier operating characteristics -- such as gain, bandpass, etc.

5.4.1 DC Gain Measurement

1. Connect test setup as shown in Figure 5.7. (The signal source need not be particularly accurate or stable, but the voltage divider must be extremely accurate. The null detector must be isolated and resolve less than 1 mV).
2. Set DC voltage source at 10 volts.
3. Adjust voltage divider so that there is no change in null detector indication when the input polarity is reversed by the reversing switch. Note ratio of voltage divider setting. Calculate gain as follows:

$$K = \frac{1}{h}$$

where K = amplifier gain
h = ratio of voltage output to input of divider.

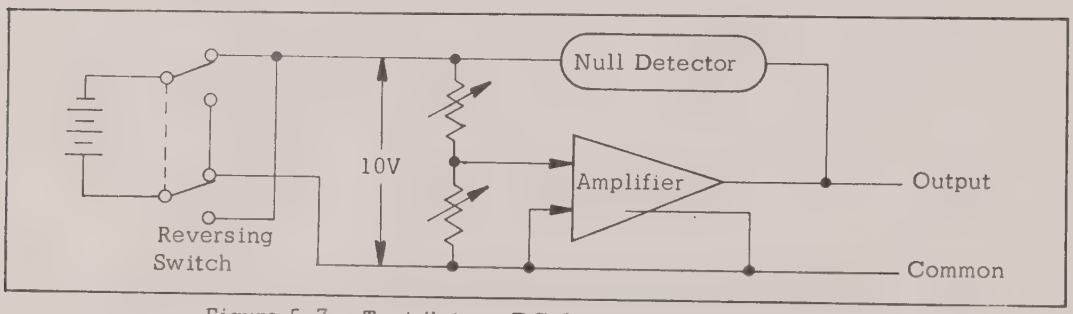


Figure 5.7 - Test Setup, DC Gain Measurement

5.4.2 Linearity Measurement

Ideally, gain should be independent of the magnitude of the output voltage from minus full scale to plus full scale. Since the Dana Amplifier's departure from this ideal is small, the null balance method of the gain measurement is again used. Linearity can be measured immediately after the DC gain measurement (see Figure 5.7). The test setup shall remain the same except that a variable DC voltage is required.

Steps 1 and 2 are followed as for DC gain Measurement (5.4.1). The input voltage is then varied from minus full scale to plus full scale, and the peak reading of the null detector recorded. The linearity in percentage can be calculated as follows:

$$\frac{\text{Peak Null Detector Reading (Volts)} \times 100}{\text{Full Scale (10 Volts)}}$$

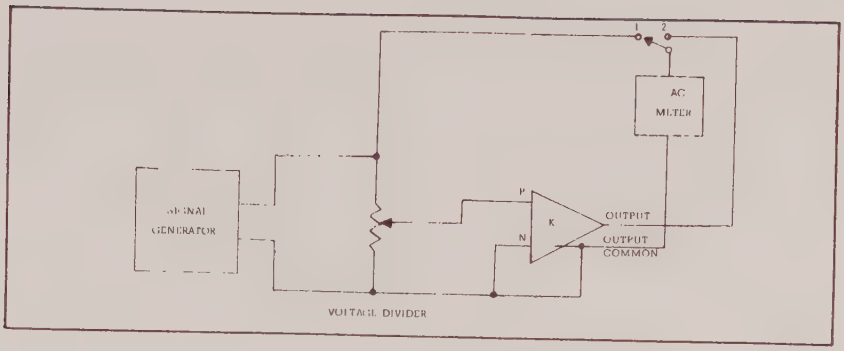


Figure 5.8 - Test Setup, AC Gain Measurement

5.4.3 AC Gain Measurement

The technique used for DC gain measurement can be extended to AC if the phase lag in the amplifier is compensated and a suitable null detector is used. If these types of measurements are anticipated, a special transformer and phase correction network may be procured from Dana; however, in general, a simpler and more direct method is described below:

1. Connect test setup as shown in Figure 5.8. (The divider should be of sufficiently low impedance to prevent errors due to source resistance. The output meter should be a good quality AC voltmeter having a mirrored scale and at least 100 minor divisions).

2. Place the monitor switch to position 1 and set the signal generator to an output of approximately 7 volts RMS at 60 Hz.

3. Select a minor division on the meter's best scale (maximum resolution and legibility) and adjust the output of the signal generator very carefully to place the needle of the meter directly on this marker. Use the mirror to avoid parallax.

4. Set the monitor switch to position 2 and adjust the voltage divider for exactly the same reading established in step 2.

5. Carefully observing the meter, move the monitor switch alternately between positions 1 and 2 to ensure that the reading is exactly the same in both positions.

6. Compute the gain of the amplifier by taking the reciprocal of the ratio set up on the voltage divider.

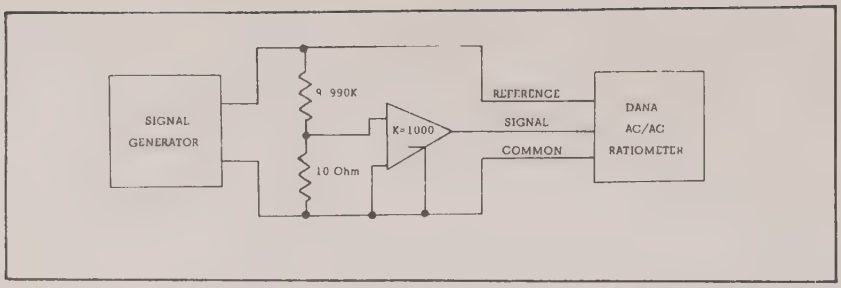


Figure 5.9 - Test Setup, High Frequency Linearity

5.4.4 High Frequency Linearity

Linearity is determined by the following equation:

$$\text{Linearity (in \%)} = 100\ \frac{E_{out} - KE_{in}}{E_{out\ (full\ scale)}}$$

To measure high frequency linearity, an extremely accurate AC/AC ratiometer is recommended such as the Dana Model 5400/060 or 5740. The measurement procedures are listed below:

1. Connect test setup as shown in Figure 5.9. Set the signal generator to approximately 7 volts RMS at 60 Hz. Set amplifier GAIN to 1000.

2. Trim the input divider and/or the amplifier vernier control until the absolute ratio is 0.99990 (displayed on ratiometer as 9.9990). This reading indicates a slight gain error; however, this is not important to the linearity measurement and allows the latter to be made with greater resolution.

3. Leaving all other adjustments set, increase the signal generator frequency to 2 kHz and observe the new reading on the ratiometer.

4. Compute linearity as follows:

$$\text{Linearity in \%} = \frac{\text{Reading 1 - Reading 2}}{1000}$$

If no range changes are involved, the result can be more quickly computed by allowing 0.001% for each digit of difference.

SECTION 6

TROUBLESHOOTING

6.1 GENERAL

Conventional instrumentation amplifiers are often difficult to troubleshoot, since the average malfunctions cause abnormal readings or signal levels to appear throughout the loop. By comparison, the Dana Amplifier is far easier to service since the various direct-coupled circuits can be readily isolated and inspected independently.

6.2 DANA REPAIR AND SERVICE POLICY

Details of Dana's repair and service policy may be found in the Dana Warranty at the rear of the manual. Items for repair should include a copy of the Dana return form describing the reason for return. Units not accompanied by this information must be held without action pending receipt of this information. A copy of this Repair/Return form is included at the rear of this manual. Additional copies may be obtained from Dana Laboratories or from Dana Sales representatives.

6.3 TROUBLESHOOTING GUIDES

Component failures may cause bias points to shift and loop gain to change such that the output voltage will move from near zero volts to a large positive or negative d-c voltage level. These levels are greater than ± 12 volts and are called "positive lockup" and "negative lockup". Three malfunctions in the amplifier can cause output lockup. These are:

- Open or short circuit
- Defective component
- Drastic change in component characteristics

The troubleshooting guides help to isolate sections of the amplifier where the malfunction may exist. The sections can be isolated without having to break or disconnect any of the loops in the amplifier.

The step-by-step troubleshooting procedure verifies that there are no open or shorted components and that the current generators are supplying the proper currents to the circuits.

A preliminary check is to be made prior to using the troubleshooting guides. Short the P input (P1-8), N input (P1-4), and Guard (P1-7) together and connect these leads to output common (P2-1). The output voltage (P2-5) with respect to common should be near zero (zero ±250 millivolt). If the output voltage is near zero, proceed to the calibration section of this manual. If the output voltage is greater than plus or minus 12 volts, the output is at lockup. Apply the troubleshooting guides in the following sequence:

1. Power Supply
2. Output Amplifier
3. Normal Mode Amplifier
4. Common Mode Amplifier
5. Feedback Network

> CAUTION
>
> The guides assume that the troubleshooter is experienced in troubleshooting solid state circuits. Non-standard practices can cause more damage to the amplifier.

Reference is made to the schematic number and assembly number where the circuit designators are located. These numbers appear at the bottom of the troubleshooting guide.

Unless the troubleshooting guide indicates otherwise, the output voltage is monitored at P2-5 (output) and P2-1 (output common).

6.4 TROUBLESHOOTNG EQUIPMENT

All of the transistors in the amplifier can be checked in the circuit. The only exception is the output transistor Q15 of the Common Mode Amplifier (see schematic 430603). Diode CR12 is across the collector to emitter leads of transistor Q15.

The following equipments are needed to troubleshoot the amplifier:

- A Simpson VOM (volt-ohmmeter) Model 260 or equivalent, can be used to check the forward and reverse resistances of the semiconductors. Disconnect the AC power prior to making these measurements.
- A 2000 ohms, 1/4 watt, carbon resistor.

- An oscilloscope or a voltmeter capable of measuring positive and negative voltages without manually changing the polarity for monitoring the output voltage of the amplifier.

- A precision ohmmeter.
  The tolerance value of most precision resistors in the amplifier is 0.1%.

- Dana Cord Set - Part Number 402469.

6.5 COMPONENT REPLACEMENT

Defective components should be replaced with components identical to the original component. Precision wirewound resistors with 0.1% tolerances should be replaced with wirewound resistors of the same tolerance value. The characteristics of the components are critical for temperature stability, zero stability, and gain stability.

The first stage dual (Q2) and the second stage dual (Q5) of the normal mode amplifier should be ordered from the factory. The first stage dual transistor is part of a kit along with four precision resistors. This stage should be replaced as a unit. The Dana part number for the first stage kit is 400708. The kit consists of a selected dual transistor (Q2) and selected wirewound resistors R38, R39, R45, and R47.

The Dana part number for the second stage dual (Q5) of the normal mode amplifier is 201285.

Dana recommends that the components be ordered from the Dana service department. Specify the part and Dana part number for the defective component.

The amplifier should be recalibrated after replacing components. Refer to the calibration procedures in Section 5.

6.6 AMPLIFIER DISASSEMBLY

1. Remove the eight number 6 Phillips Flat-Head screws from the aluminum support (right-hand side of the amplifier as viewed from the front panel).

2. Slide the dust cover (left-hand side) to the rear of the amplifier. Remove the dust cover from the aluminum support. Refer to figure 6.1a.

3. To remove the aluminum support, remove six number 4, Phillips pan-head screws and lock washers. These screws hold the circuit board assembly to the aluminum support. Do not remove the six number 8, Phillips pan-head screws and lock washers at this time. Three are located at the front of the circuit board and the remaining three are at the back of the circuit board. Slide the aluminum support to the rear of the amplifier and remove. Do not allow the weight of the aluminum support to bend the circuit board assembly as breakage may occur. Refer to figure 6.1b.

4. The guard box encloses the Input Amplifier and Feedback Network. To remove the guard box cover, remove two, number 4, Phillips pan-head screws at the top of the cover and lift the cover from the guard box. The guard box is shown in Figure 6.1c.

5. The etched-circuit side of the Input Amplifier is electrically guarded by a fiberglass guard plate. The guard plate is held to two standoffs by two, number 4, Phillips flat-head screws. Remove the guard plate to probe the etched circuit side of the Input Amplifier.

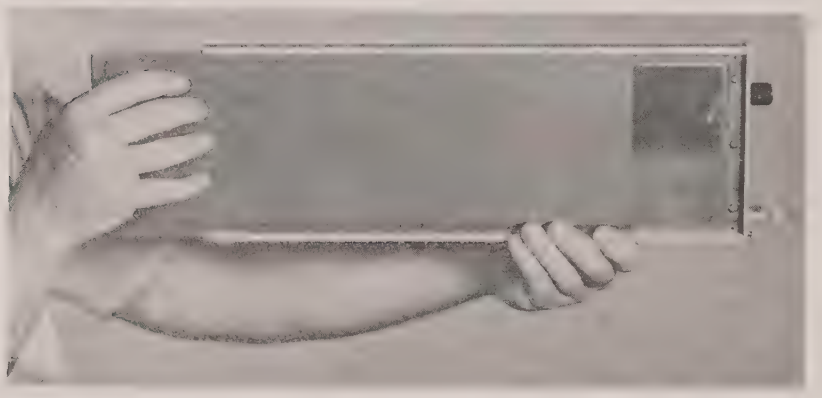


Figure 6.1 a

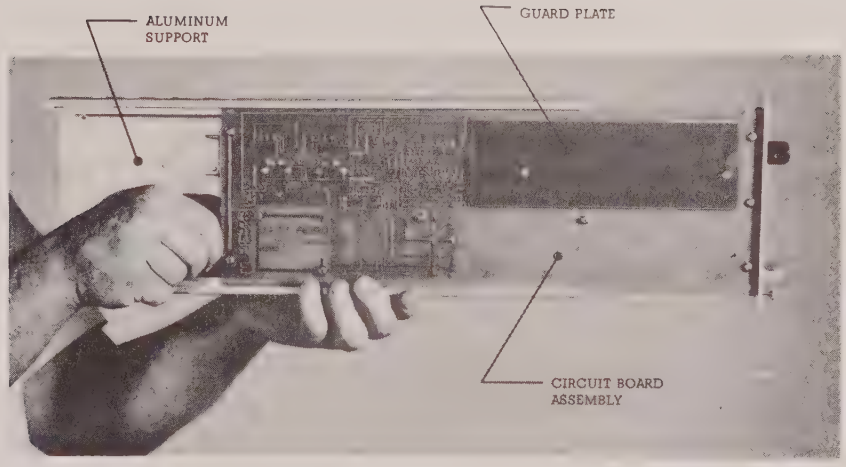


Figure 6.1 b

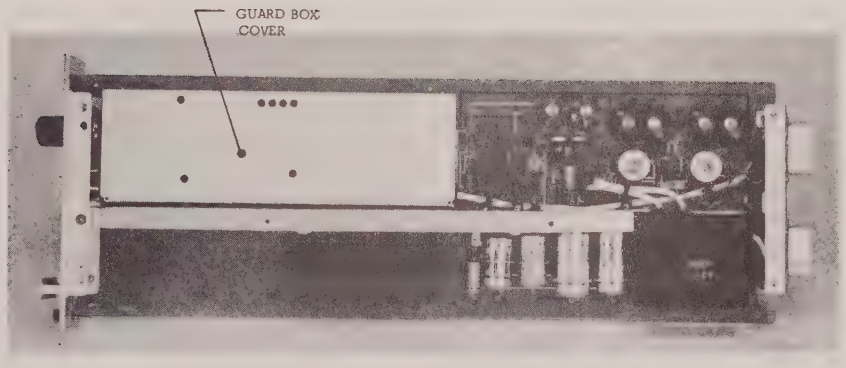


Figure 6.1 c

TROUBLESHOOTING GUIDES

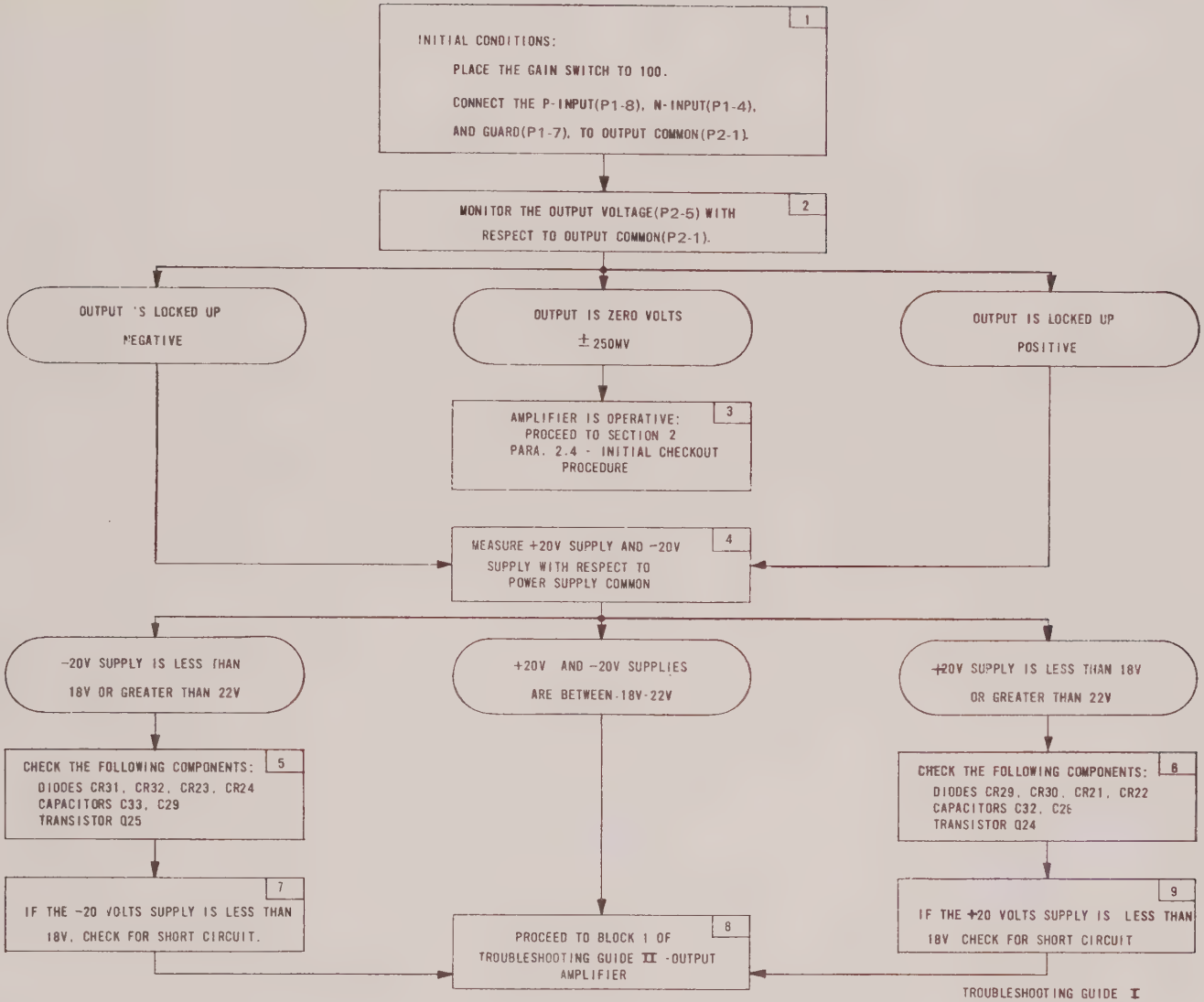
Power Supply I

Output Amplifier II

Normal Mode Amplifier (2 sheets) III

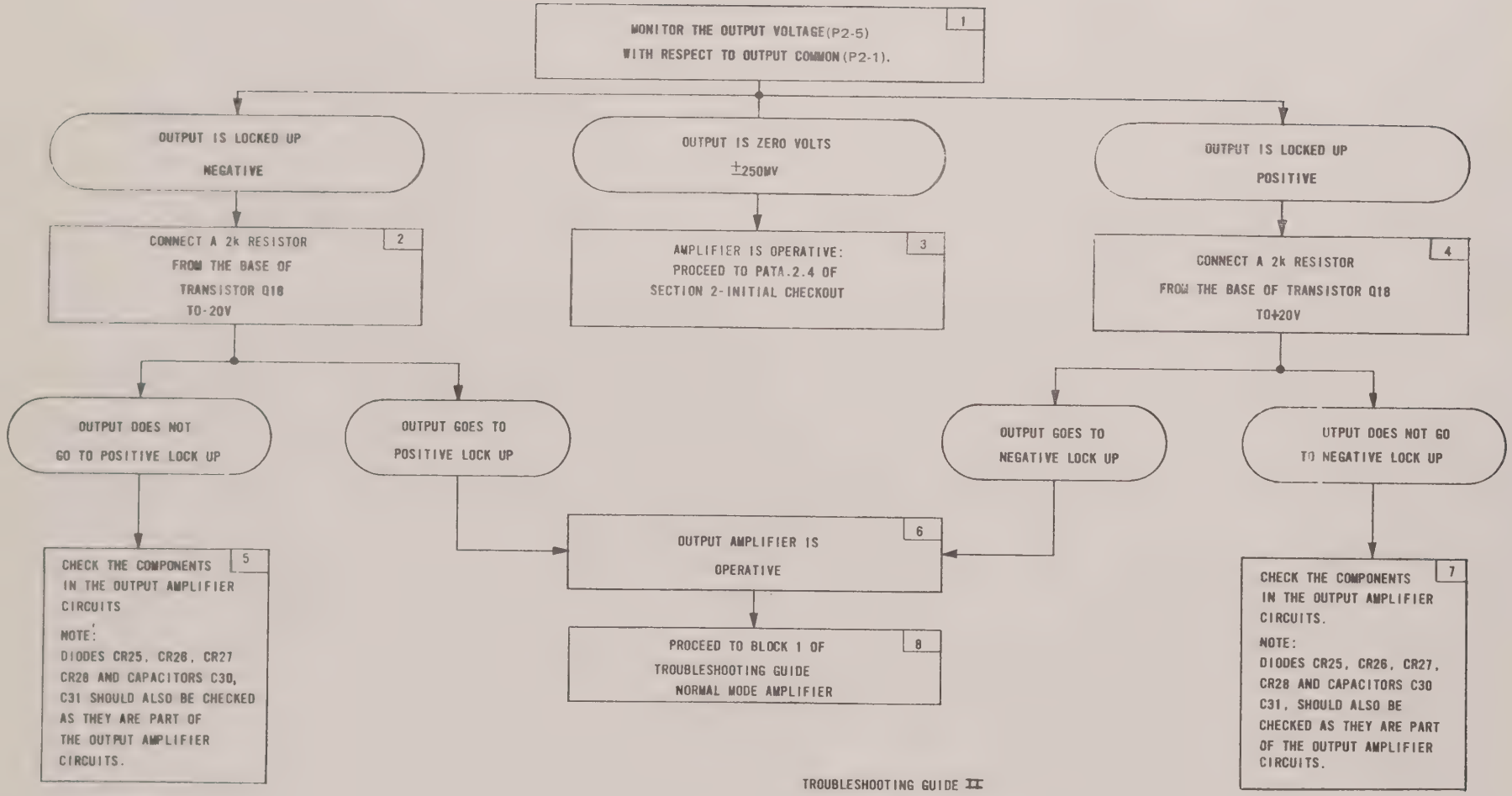
Common Mode Amplifier IV

Feedback Network V



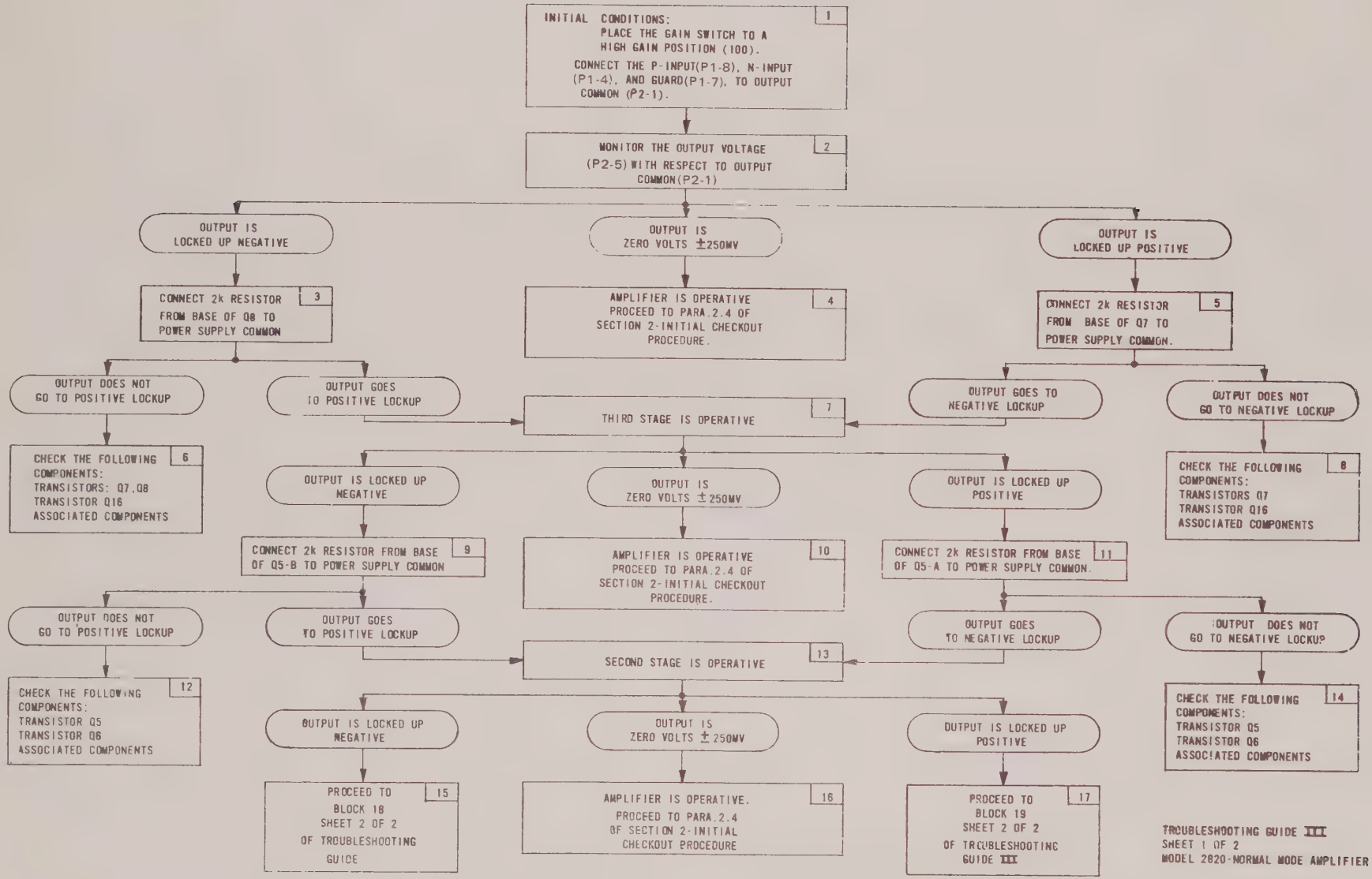
TROUBLESHOOTING GUIDE I
SHEET 1 OF 1
MODEL 2820- POWER SUPPLY

OPTION	SCHEMATIC	ASSEMBLY
V1	430603	402303
V2	430604	402304
V3	430602	402390



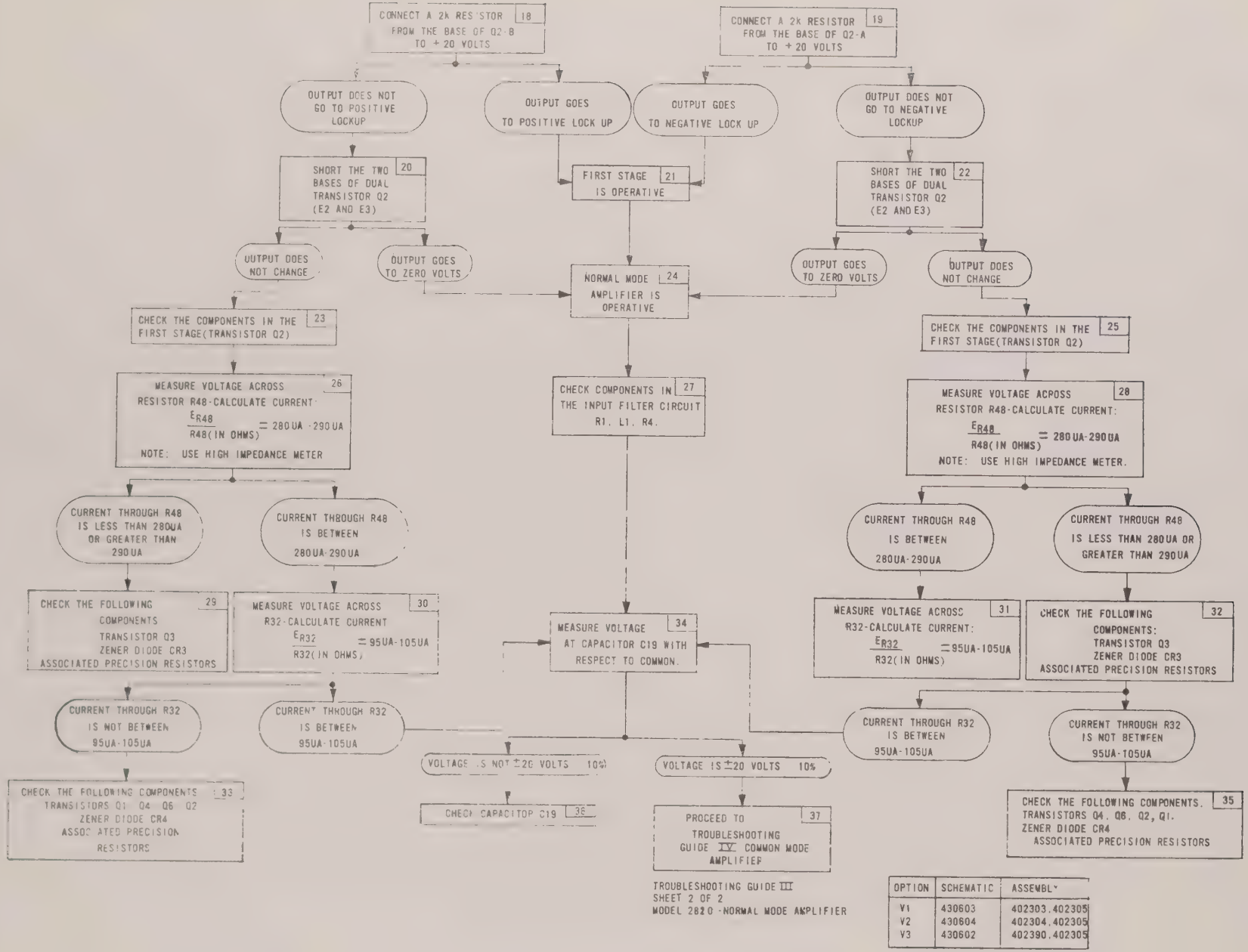
TROUBLESHOOTING GUIDE II
SHEET 1 OF 1
MODEL 2820-100MA OUTPUT AMPLIFIER

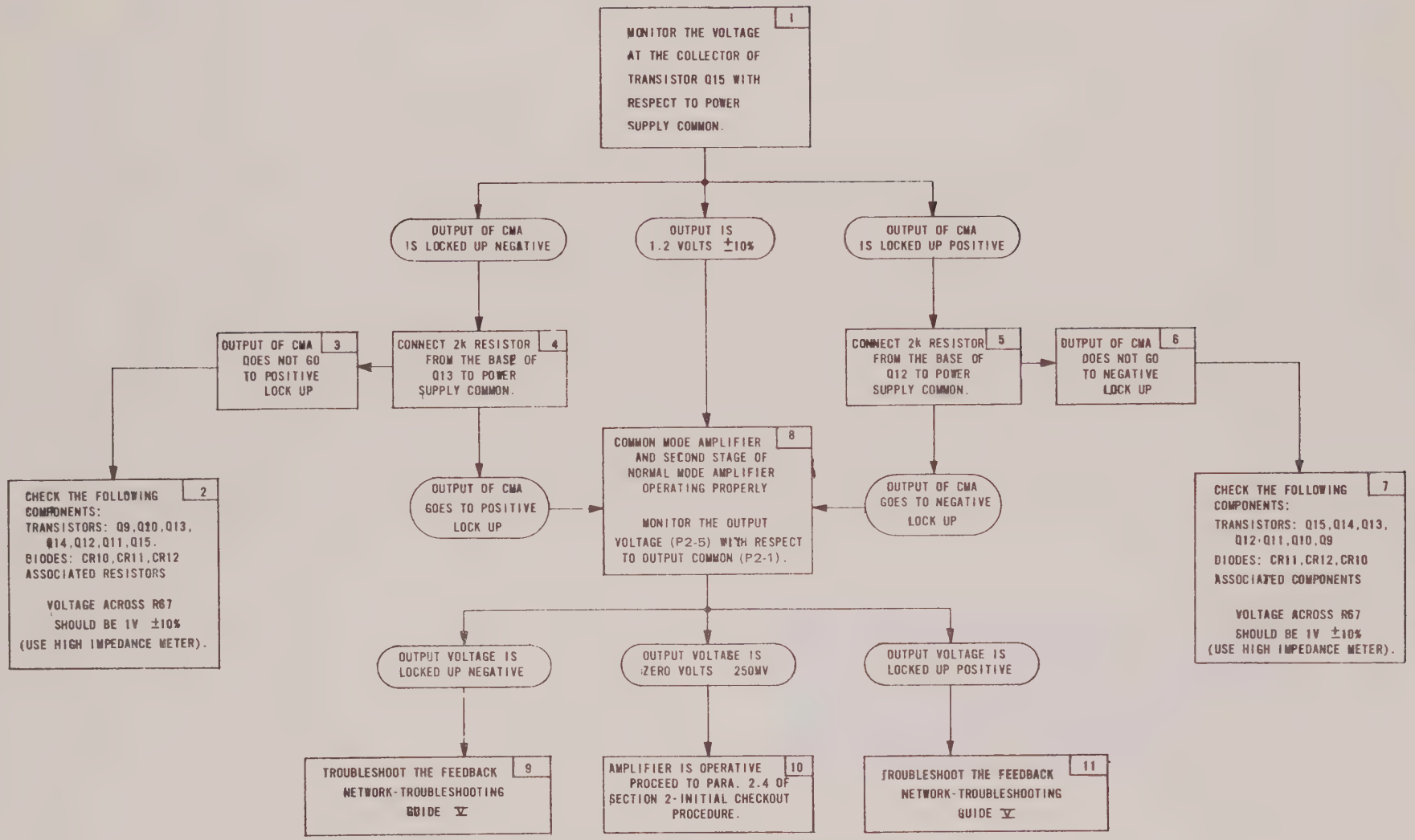
OPTION	SCHEMATIC	ASSEMBLY
V1	430603	402303
V2	430604	402304
V3	430602	402390


1
INITIAL CONDITIONS:
PLACE THE GAIN SWITCH TO A HIGH GAIN POSITION (100).
CONNECT THE P-INPUT(P1-8), N-INPUT (P1-4), AND GUARD(P1-7), TO OUTPUT COMMON (P2-1).
2
MONITOR THE OUTPUT VOLTAGE (P2-5) WITH RESPECT TO OUTPUT COMMON(P2-1)
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO VOLTS ±250MV
OUTPUT IS LOCKED UP POSITIVE
3
CONNECT 2k RESISTOR FROM BASE OF Q8 TO POWER SUPPLY COMMON
4
AMPLIFIER IS OPERATIVE PROCEED TO PARA.2.4 OF SECTION 2-INITIAL CHECKOUT PROCEDURE.
5
CONNECT 2k RESISTOR FROM BASE OF Q7 TO POWER SUPPLY COMMON.
OUTPUT DOES NOT GO TO POSITIVE LOCKUP
OUTPUT GOES TO POSITIVE LOCKUP
OUTPUT GOES TO NEGATIVE LOCKUP
OUTPUT DOES NOT GO TO NEGATIVE LOCKUP
7
THIRD STAGE IS OPERATIVE
6
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS: Q7,Q8
TRANSISTOR Q16
ASSOCIATED COMPONENTS
8
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS Q7
TRANSISTOR Q16
ASSOCIATED COMPONENTS
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO VOLTS ±250MV
OUTPUT IS LOCKED UP POSITIVE
9
CONNECT 2k RESISTOR FROM BASE OF Q5-B TO POWER SUPPLY COMMON
10
AMPLIFIER IS OPERATIVE PROCEED TO PARA.2.4 OF SECTION 2-INITIAL CHECKOUT PROCEDURE.
11
CONNECT 2k RESISTOR FROM BASE OF Q5-A TO POWER SUPPLY COMMON.
OUTPUT DOES NOT GO TO POSITIVE LOCKUP
OUTPUT GOES TO POSITIVE LOCKUP
OUTPUT GOES TO NEGATIVE LOCKUP
OUTPUT DOES NOT GO TO NEGATIVE LOCKUP
13
SECOND STAGE IS OPERATIVE
12
CHECK THE FOLLOWING COMPONENTS:
TRANSISTOR Q5
TRANSISTOR Q6
ASSOCIATED COMPONENTS
14
CHECK THE FOLLOWING COMPONENTS:
TRANSISTOR Q5
TRANSISTOR Q6
ASSOCIATED COMPONENTS
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO VOLTS ±250MV
OUTPUT IS LOCKED UP POSITIVE
15
PROCEED TO BLOCK 18 SHEET 2 OF 2 OF TROUBLESHOOTING GUIDE
16
AMPLIFIER IS OPERATIVE.
PROCEED TO PARA.2.4 OF SECTION 2-INITIAL CHECKOUT PROCEDURE
17
PROCEED TO BLOCK 19 SHEET 2 OF 2 OF TROUBLESHOOTING GUIDE III

TROUBLESHOOTING GUIDE III
SHEET 1 OF 2
MODEL 2820-NORMAL MODE AMPLIFIER

OPTION	SCHEMATIC	ASSEMBLY
V1	430603	402303, 402305
V2	430604	402304, 402305
V3	430602	402390, 402305


CONNECT A 2k RESISTOR 18 FROM THE BASE OF Q2-B TO +20 VOLTS
CONNECT A 2k RESISTOR 19 FROM THE BASE OF Q2-A TO +20 VOLTS
OUTPUT DOES NOT GO TO POSITIVE LOCKUP
OUTPUT GOES TO POSITIVE LOCK UP
OUTPUT GOES TO NEGATIVE LOCK UP
OUTPUT DOES NOT GO TO NEGATIVE LOCKUP
SHORT THE TWO BASES OF DUAL TRANSISTOR Q2 (E2 AND E3) 20
FIRST STAGE 21 IS OPERATIVE
SHORT THE TWO BASES OF DUAL TRANSISTOR Q2 (E2 AND E3) 22
OUTPUT DOES NOT CHANGE
OUTPUT GOES TO ZERO VOLTS
NORMAL MODE 24 AMPLIFIER IS OPERATIVE
OUTPUT GOES TO ZERO VOLTS
OUTPUT DOES NOT CHANGE
CHECK THE COMPONENTS IN THE FIRST STAGE(TRANSISTOR Q2) 23
CHECK THE COMPONENTS IN THE FIRST STAGE(TRANSISTOR Q2) 25
MEASURE VOLTAGE ACROSS RESISTOR R48-CALCULATE CURRENT: E R48 / R48(IN OHMS) = 280UA-290UA NOTE: USE HIGH IMPEDANCE METER 26
CHECK COMPONENTS IN THE INPUT FILTER CIRCUIT R1, L1, R4. 27
MEASURE VOLTAGE ACROSS RESISTOR R48-CALCULATE CURRENT: E R48 / R48(IN OHMS) = 280UA-290UA NOTE: USE HIGH IMPEDANCE METER. 28
CURRENT THROUGH R48 IS LESS THAN 280UA OR GREATER THAN 290UA
CURRENT THROUGH R48 IS BETWEEN 280UA-290UA
CURRENT THROUGH R48 IS BETWEEN 280UA-290UA
CURRENT THROUGH R48 IS LESS THAN 280UA OR GREATER THAN 290UA
CHECK THE FOLLOWING COMPONENTS TRANSISTOR Q3 ZENER DIODE CR3 ASSOCIATED PRECISION RESISTORS 29
MEASURE VOLTAGE ACROSS R32-CALCULATE CURRENT E R32 / R32(IN OHMS) = 95UA-105UA 30
MEASURE VOLTAGE AT CAPACITOR C19 WITH RESPECT TO COMMON. 34
MEASURE VOLTAGE ACROSS R32-CALCULATE CURRENT: E R32 / R32(IN OHMS) = 95UA-105UA 31
CHECK THE FOLLOWING COMPONENTS: TRANSISTOR Q3 ZENER DIODE CR3 ASSOCIATED PRECISION RESISTORS 32
CURRENT THROUGH R32 IS NOT BETWEEN 95UA-105UA
CURRENT THROUGH R32 IS BETWEEN 95UA-105UA
CURRENT THROUGH R32 IS BETWEEN 95UA-105UA
CURRENT THROUGH R32 IS NOT BETWEEN 95UA-105UA
VOLTAGE IS NOT ±20 VOLTS 10%
VOLTAGE IS ±20 VOLTS 10%
CHECK THE FOLLOWING COMPONENTS TRANSISTORS Q1 Q4 Q6 Q2 ZENER DIODE CR4 ASSOCIATED PRECISION RESISTORS 33
CHECK CAPACITOR C19 36
PROCEED TO TROUBLESHOOTING GUIDE IV COMMON MODE AMPLIFIER 37
CHECK THE FOLLOWING COMPONENTS. TRANSISTORS Q4, Q6, Q2, Q1. ZENER DIODE CR4 ASSOCIATED PRECISION RESISTORS 35
TROUBLESHOOTING GUIDE III SHEET 2 OF 2 MODEL 2820 -NORMAL MODE AMPLIFIER
OPTION | SCHEMATIC | ASSEMBLY
V1 | 430603 | 402303, 402305
V2 | 430604 | 402304, 402305
V3 | 430602 | 402390, 402305

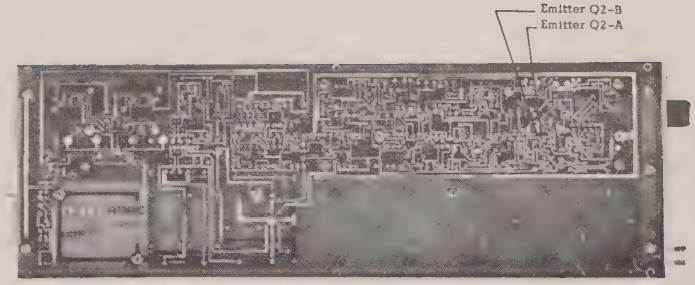

1
MONITOR THE VOLTAGE AT THE COLLECTOR OF TRANSISTOR Q15 WITH RESPECT TO POWER SUPPLY COMMON.
OUTPUT OF CMA IS LOCKED UP NEGATIVE
OUTPUT IS 1.2 VOLTS ±10%
OUTPUT OF CMA IS LOCKED UP POSITIVE
3
OUTPUT OF CMA DOES NOT GO TO POSITIVE LOCK UP
4
CONNECT 2k RESISTOR FROM THE BASE OF Q13 TO POWER SUPPLY COMMON.
5
CONNECT 2k RESISTOR FROM THE BASE OF Q12 TO POWER SUPPLY COMMON.
6
OUTPUT OF CMA DOES NOT GO TO NEGATIVE LOCK UP
2
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS: Q9,Q10,Q13, Q14,Q12,Q11,Q15.
DIODES: CR10,CR11,CR12
ASSOCIATED RESISTORS
VOLTAGE ACROSS R67 SHOULD BE 1V ±10%
(USE HIGH IMPEDANCE METER).
OUTPUT OF CMA GOES TO POSITIVE LOCK UP
8
COMMON MODE AMPLIFIER AND SECOND STAGE OF NORMAL MODE AMPLIFIER OPERATING PROPERLY
MONITOR THE OUTPUT VOLTAGE (P2-5) WITH RESPECT TO OUTPUT COMMON (P2-1).
OUTPUT OF CMA GOES TO NEGATIVE LOCK UP
7
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS: Q15,Q14,Q13, Q12·Q11,Q10,Q9
DIODES: CR11,CR12,CR10
ASSOCIATED COMPONENTS
VOLTAGE ACROSS R67 SHOULD BE 1V ±10%
(USE HIGH IMPEDANCE METER).
OUTPUT VOLTAGE IS LOCKED UP NEGATIVE
OUTPUT VOLTAGE IS ZERO VOLTS 250MV
OUTPUT VOLTAGE IS LOCKED UP POSITIVE
9
TROUBLESHOOT THE FEEDBACK NETWORK-TROUBLESHOOTING GUIDE V
10
AMPLIFIER IS OPERATIVE PROCEED TO PARA. 2.4 OF SECTION 2-INITIAL CHECKOUT PROCEDURE.
11
TROUBLESHOOT THE FEEDBACK NETWORK-TROUBLESHOOTING GUIDE V

TROUBLESHOOTING GUIDE IV
SHEET 1 OF 1
MODEL 2820-COMMON MODE AMPLIFIER (CMA)

OPTION	SCHEMATIC	ASSEMBLY
V1	430603	402303
V2	430604	402304
V3	430602	402390

1 — REMOVE THE AC POWER FROM THE AMPLIFIER.
FOR V2 OPTION-PLACE THE MULTIPLIER SWITCH TO THE X1 POSITION

2 — MEASURE THE RESISTANCE BETWEEN THE EMITTERS OF TRANSISTOR Q2



3 — THE RESISTANCE VALUE FOR EACH GAIN POSITION SHOULD BE:

GAIN	RESISTANCE
20	13.50k ±1%
50	5.38k ±1%
100	2.73k ±1%
200	1.37k ±1%
500	.539k ±1%
1000	.275k ±1%

SOME RESISTANCE VALUES, BUT NOT ALL RESISTANCE VALUES ARE OUT OF TOLERANCE

4 — CHECK THE GAIN RESISTOR.

GAIN	RESISTOR
50	R15
100	R16
200	R17
500	R18
1000	R19

ALL RESISTANCE MEASUREMENTS ARE OUT OF TOLERANCE

5 — CHECK THE RESISTORS IN THE FEEDBACK NETWORK:
R20, R24, R21, R23, R26, AND POTENTIOMER R25

CHECK RESISTORS R40, R41, R42, R43, R44, AND R46
CHECK R45 AND R47, THE VALUES OF THESE TWO RESISTORS ARE STAMPED ON THE RESISTOR

RESISTANCE VALUES ARE WITHIN TOLERANCE

6 — APPLY THE AC POWER TO THE AMPLIFIER.
PLACE THE GAIN SWITCH TO A HIGH GAIN POSITION(100)
CONNECT THE P-INPUT(P1-8) N-INPUT(P1-4) AND GUARD(P1-7) TO OUTPUT COMMON (P2-1).

OUTPUT IS LOCKED UP POSITIVE OR NEGATIVE

7 — MONITOR THE OUTPUT (P2-5) WITH RESPECT TO OUTPUT COMMON(P2-1).

8 — MAKE CERTAIN NONE OF THE TROUBLESHOOTING STEPS WERE OVERLOOKED.
RETURN AMPLIFIER TO DANA LABORATORIES ALONG WITH REPAIR/RETURN FORM.

OUTPUT IS ZERO ±250MV

9 — PROCEED TO PARA.2.4 OF SECTION 2- INITIAL CHECKOUT PROCEDURE

TROUBLESHOOTING GUIDE I
SHEET 1 OF 1
MODEL 2820-FEEDBACK NETWORK

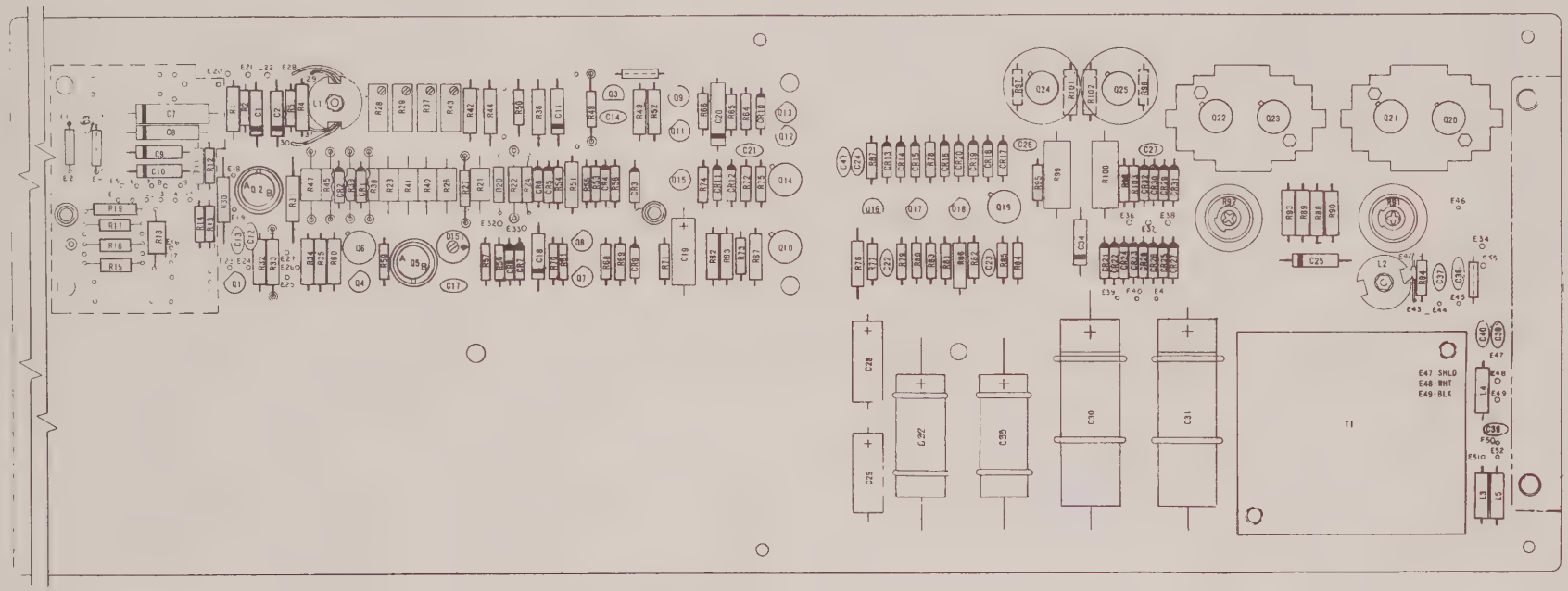
OPTION	SCHEMATIC	ASSEMBLY
V1	430603	402303
V2	430604	402304
V3	430602	402390

SECTION 7

DRAWINGS AND PARTS LISTS

7.1 DRAWINGS

PC Board Assembly - Amp 2820 V1	402939
Schematic - Amp 2820 V1	430603
PC Board Assembly - Amp 2820 V2	402940
Schematic - Amp 2820 V2	430604
PC Board Assembly - Amp 2820 V3	403056
Schematic - Amp 2820 V3	430602
Outline Dimensional Amp Model 2820	452400
Outline Dimensional Enclosure 2808-1	452402
Outline Dimensional Enclsoure 2808-2	452403
Wiring Diagram 2808-1	430590
Wiring Diagram 2808-2	430591
Enclosure Assembly 2802-2	402948



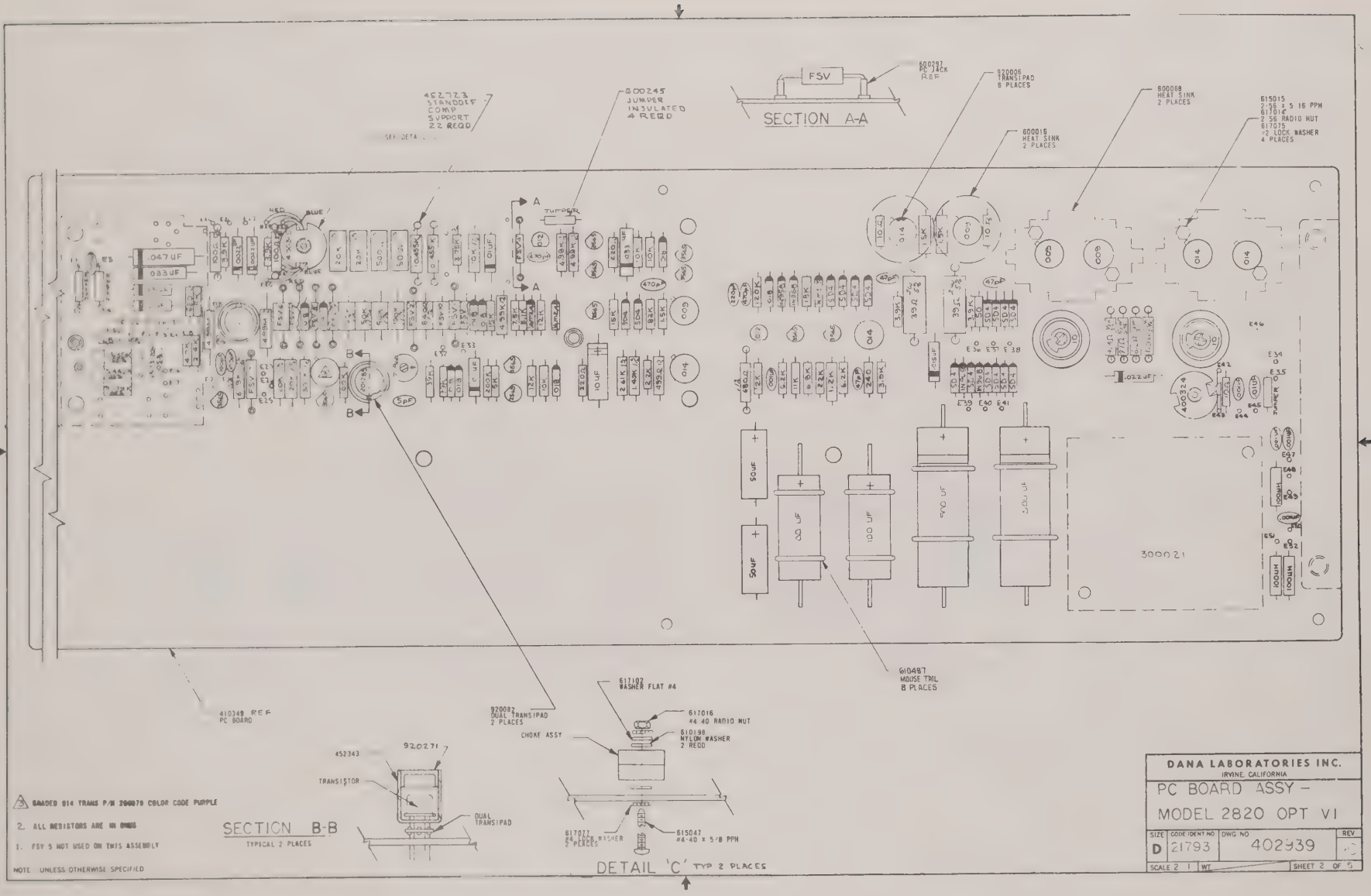
NOTE: UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P. C. BOARD ASSY—
MODEL 2820 OPT V1

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402939	C

SCALE 2 / 1 | WT | SHEET 1 OF 5



△ SHADED 814 TRANS P/N 200879 COLOR CODE PURPLE

2. ALL RESISTORS ARE IN OHMS

1. FSV'S NOT USED ON THIS ASSEMBLY

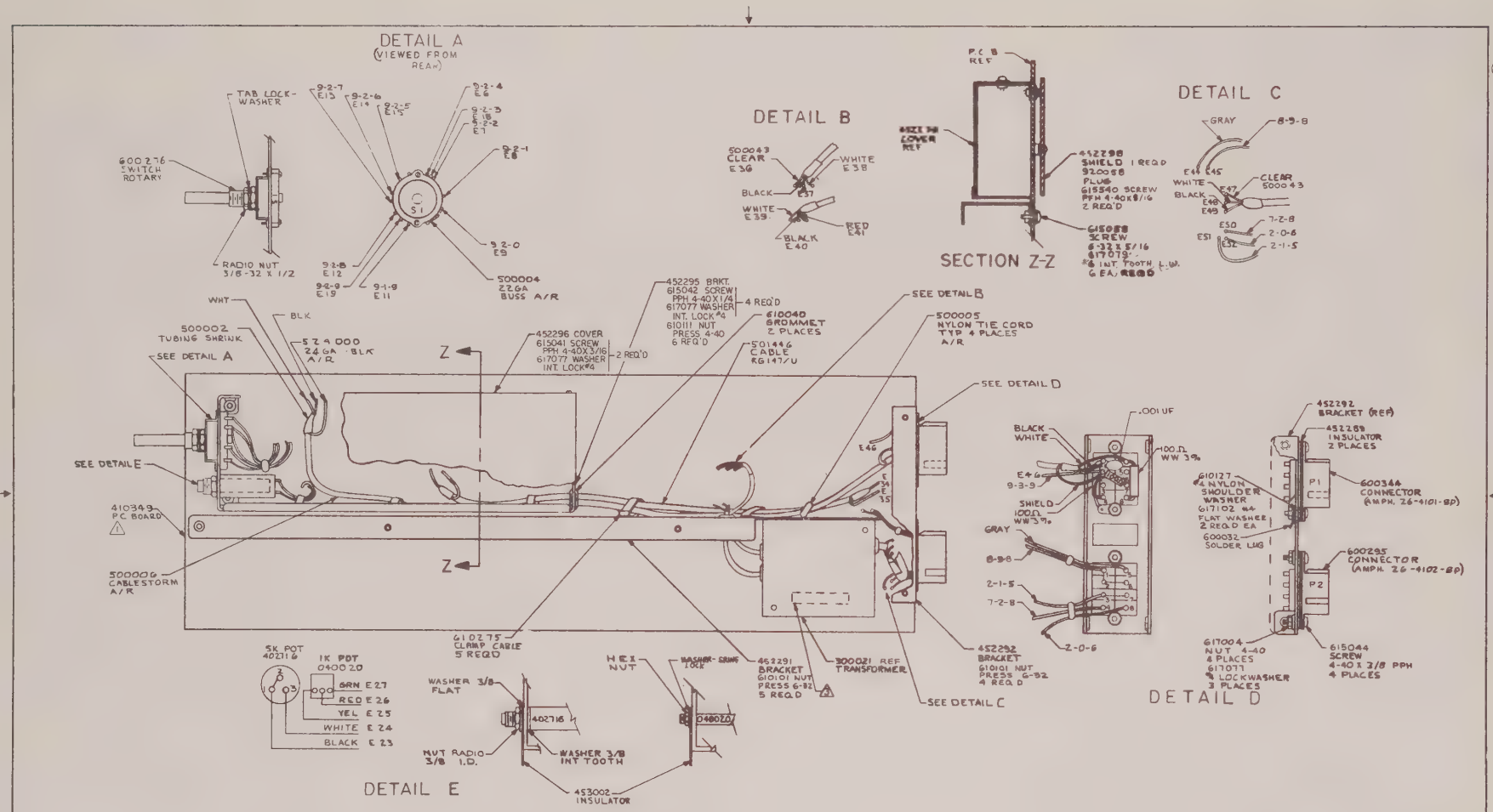
NOTE UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASSY -
MODEL 2820 OPT V1

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	402939	

SCALE 2 | WT | SHEET 2 OF 5



5. FACTORY SELECT VALUES (FSV) TO BE DETERMINED BY BOARD NO. 402716
4. SCHEMATIC REF 420043
⚠ RUBBER STAMP TOP ASSY PART NO. & LATEST REVISION WHERE SHOWN. PARTS BOS
2. ASSEMBLY PROCEDURES AND PROCESSES TO COMPORM WITH DANA WORKMANSHIP STANDARDS
⚠ P C BOARD VIEWED FROM COMPONENT SIDE

NOTES: UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BOARD ASSY—
MODEL 2820 OPT V1

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402939	C

SCALE 1/1 SHEET 3 OF 5

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C1	121092	.0022UF/100V	2
	121092	.0022UF 100V	REF
	10117	.001UF DISC	1
		NOT USED	
		NOT USED	
		NOT USED	
	121093	[illegible]	
	121091	[illegible]	2
	121087	.015UF 100V	2
		.01UF 100V	1
		.01UF 100V	REF
		100pF DISC	
		10upF DISC	REF
		470pF DISC	REF
	10024	2-8pF VARIABLE	REF
		NOT USED	
	10005	5pF DISC	REF
C19	122089	[illegible]	REF
	112621	[illegible]	1
C21	121081	.033UF 100V	REF
	10184	470pF DISC	REF
	10024	.001UF DISC	REF
C23	10197	47pF DISC	3
C24	91647	470pF DISC	REF
C25	10468	.022UF 100V	1
C26	101182	47pF DISC	REF
C27	101182	47pF DISC	REF
C28	110080	50UF 25V	2
C29	110080	50UF 25V	REF
C30	110065	500UF 50V	2
C31	110065	500UF 50V	REF
C32	110081	100UF 50V	2

REF DES OR ITEM	P/N	DESCRIPTION	QTY
CR21	210084	SD4	REF
CR22	220011	IN9088	REF
CR23	220011	IN9088	REF
CR24	210084	SD4	REF
CR25	210084	SD4	REF
CR26	210084	SD4	REF
CR27	210084	SD4	REF
CR28	210084	SD4	REF
CR29	210084	SD4	REF
CR30	210084	SD4	REF
CR31	210084	SD4	REF
CR32	210084	SD4	REF
L1	4003-5	RF CHOKE	1
L2	4003-4	90uh	1
L3	340033	100UH	3
L4	340033	100UH	REF
L5	340033	100UH	REF
Q1	290043	2N3605	11
Q2	[illegible]	FSV ASSY	REF
Q3	290022	817	3
Q4	290043	2N3605	REF
Q5	201265	2ND STAGE DUAL	1
Q6	200078	814 (SELECT)	1
Q7	290043	2N3605	REF
Q8	290043	2N3605	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R12	[illegible]	1.8k	2
R13	090242	2 4k	1
R14	000472	4 7k	1
R15	070424	8 170k, 89% 1%	1
R16	070423	3 442k, 89% 1%	1
R17	070422	1 530k, 89% 1%	1
R18	070421	973 7Ω 89% 1%	1
R19	020420	2810Ω 89% 1%	1
R20	402717	FSV ASSY	REF
R21	020086	840 OHMS 1% 1%	1
R22	402716	FSV ASSY	REF
R23	020079	180k 1% 1%	2
R24	402716	FSV ASSY	REF
R25	402716	FSV ASSY	REF
R26	020079	100k 1% 1%	REF
R27	402716	FSV ASSY	REF
R28	040092	20k POT	2
R29	040092	20k POT	REF
R30	011178	4 9k 1%	2
R31	011178	4 9k 1%	REF
R32	[illegible]	5 10k 1%	1
R33	402716	FSV ASSY	REF
R34	[illegible]	20k 1%	2
R35	010058	20k 1%	REF
R36	010116	10k 1%	1
R37	040093	500 OHMS POT	REF
R38	402716	FSV ASSY	REF
R39	[illegible]	FSV ASSY	REF
R40	020078	50k 1% 1%	2
R41	020078	50k 1% 1%	REF
R42	0284.25	10 455k 1%M20CF	2
R43	040100	50 OHMS POT	1
R44	0284.25	10 400k 1%M20CF	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R45	402716	FSV ASSY	REF
R46	040020	1k POT	1
R47	402716	FSV ASSY	REF
R48	402716	FSV ASSY	REF
R49	010020	4 99k 1%M20	3
R50	020104	3 76k 1% 1%	1
R51	010020	4 99k 1%M20	REF
R52	010020	4 99k 1%M20	REF
R53	000512	5 1k	1
R54	000153	15k	3
R55	000752	7.5k	1
R56	000123	12k	3
R57	000383	38k	2
R58	000383	38k	REF
R59	000184	10Ωk	1
R60	010018	3 01k 1%M20	1
R61	000153	15k	REF
R62	011534	2 81k 1%M20	1
R63	010088	1 40k 1%M20	1
R64	000103	10k	3
R65	000103	10k	REF
R66	000221	220 OHMS	2
R67	010027	400 OHMS 1%M20	1
R68	000123	12k	REF
R69	000163	16k	REF
R70	000264	200k	1
R71	000221	220 OHMS	REF
R72	000023	82k	1
R73	000222	2 2k	1
R74	000160	10k	REF
R75	000182	1 8k	REF
R76	020110	800+20 1% 1%	1
R77	000123	12k	REF
R78	000100	40k	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R79	000827	6 2k	2
R80	000113	11k	1
R81	000123	22k	1
R82	000872	8 2k	REF
R83	000687	6 8k	1
R84	000382	3 9k	REF
R85	000243	240 OHMS	1
R86	001488	1 2k 1/2W 5%	1
R87	000124	120k	1
R88	000740	8 2 OHMS 1/2W 5%	1
R89	001741	8 1 OHMS 1/2W 5%	1
R90	001798	1 5 OHMS 1.2W 5%	1
R91	041478	10CLPOT(CTS)	2
R92	041476	10COPOT(CTS)	REF
R93	001739	4 3 OHMS 1/2W 5%	1
R94	000100	[illegible]	3
R95	000382	3 9k	REF
R96	000382	3 9k	REF
R97	040100	[illegible]	REF
R98	000120	10 OHMS	REF
R99	030003	30 OHMS 2W 5%	2
R100	030003	30 OHMS 2W 5%	REF
R101	001683	1 5k 1/2W 5%	2
R102	001682	1.5k 1/2W 5%	REF
R103	000151	150 OHMS	1
R104	020106	[illegible]	REF
R105	020106	100 OHMS 1% 3%	REF
R106	000101	[illegible]	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
T1	300021	TRANSFORMER	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	402717	FSV ASSEMBLY	1
	410348	PCB AMPL 1000 OP	1
	420347	PCB ARTWORK	REF
	430603	SCHEMATIC	REF
	452289	INSULATOR	2
	452291	BRACKET-SUPPORT	1
	452292	BRACKET-CONN MTG	1
	452295	BRACKET-ELEC SHIELD	1
	452296	COVER ELEC SHIELD	1
	452295	SHIELD ELECSTAT	1
	452343	CASE-MODIFIED 9202250 MT GLASS [illegible]	2
	453002	INSL POT MTG	1
	452723	STANDOFF 6MM	22
	500002	[illegible] 153 I D	A/R
	500004	[illegible] TAPE	A/R
	500005	NYLON TIE CORD	A/R
	500006	CABLE WRAP 824 W/30M S2W	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	500043	WIRE-24GA TEFLON COATED	A/R
	501378	TEFLON TUBING Teflon	W/R
	501448	CABLE GR 174/U 1 COND 20AWG SLD	A/R
	524000	WIRE 24GA STR 0 COLOR	A/R
	524206	WIRE 24GA STR, 2-8-6 COLOR	A/R
	524215	WIRE 24GA STR 2-1-5 COLOR	A/R
	524228	WIRE 24GA STR 7-2-8 COLOR	A/R
	524000	WIRE 24GA STR [illegible]	A/R
	524004	WIRE 24GA STR 0-0-4 COLOR	A/R
	524010	WIRE 24GA STR 0-1-0 COLOR	A/R
	524012	WIRE 24GA STR 0-1-2 COLOR	A/R
	524013	WIRE 24GA STR 0-1-3 COLOR	A/R
	524014	WIRE 24GA STR 0-1-4 COLOR	A/R
	524015	WIRE 24GA STR 0-1-5 COLOR	A/R
	524018	WIRE 24GA STR [illegible]	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	524020	WIRE 24GA STR 0-2-0 COLOR	A/R
	524021	WIRE 24GA STR 0-2-1 COLOR	A/R
	524022	WIRE 24GA STR 0-2-2 COLOR	A/R
	524023	WIRE 24GA STR 0-2-3 COLOR	A/R
	524024	WIRE 24GA STR 0-2-4 COLOR	A/R
	524025	WIRE 24GA STR 0-2-5 COLOR	A/R
	524026	WIRE 24GA STR 0-2-6 COLOR	A/R
	524027	WIRE 24GA STR 0-2-7 COLOR	A/R
	524028	WIRE 24GA STR 0-2-8 COLOR	A/R
	524029	WIRE 24GA STR 0-2-9 COLOR	A/R
	524030	WIRE 24GA STR 0-3-0 COLOR	A/R
	524031	WIRE 24GA STR 0-3-1 COLOR	A/R
	524032	WIRE 24GA STR 0-3-2 COLOR	A/R
	524034	WIRE 24GA STR 0-3-4 COLOR	A/R
	524035	WIRE 24GA STR 0-3-5 COLOR	A/R
	524036	WIRE 24GA STR 0-3-6 COLOR	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	524038	WIRE 24GA STR 0-3-8 COLOR	A/R
	524068	WIRE 24GA STR 0-6-8 COLOR	A/R
	600010	[illegible] TXBF-632-0258	2
	600002	[illegible] SMITH 1418-4	1
	600006	HEAT DISS (ERC LP5030	2
	600245	JUMPER-INSULATED	2
	600276	SWITCH-ROTARY	1
	600285	PLUG-CONN 6 PIN AMPH 28-4102-6P	1
	600297	CONN PC JACK	18
	600344	CONN 8 PIN AMPH 28-4101-8P	1
	610457	TIE STRAP 'MOUSETAIL'	8
	610040	GROMMET-RUBBER 1/4 I.D.	2
	610101	NUT-PRESS 8-32 PEM S-632-1	8
	610111	NUT PRESS 4-40 PEM S-440-1	8
	610127	[illegible]	2
	610188	[illegible]	6

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	610252	STDOFF-SW 4 40 X 1/8 LG 1/4O 08 MTG	2
	610275	CLAMP-CABLE PL BUDBIG 3-4-1	5
	615015	SCREW PPH 2-56 X 5/16	4
	615034	SCREW PPH 4-40 X 3/16	2
	615042	SCREW PPH 4-40 X 1/4 LG.	4
	615044	SCREW PPH 4-40 X 3/8 LG	4
	615047	SCREW PPH 4-40 X 5/8 LG	2
	615058	SCREW PPH 8-32 X 5/16 LG	8
	615540	SCREW FLAT HD 4-40 X 3/16 LG	2
	617004	NUT-HEX 4-40	4
	617014	NUT-HEX 2-56 RADIO	4
	617048	NUT-HEX 4-40 RADIO	2
	617075	INT TH LOCK - WASHER #2	4
	617077	INT TH LOCK - WASHER #4	13
	617078	INT TH LOCK - [illegible]	8
	617102	WASHER-FLAT #4	4

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	020004	TRANS PAD LRG	8
	020010	SOLDER-BAR 60/37	A/R
	020026	SOLDER-WIRE	A/R
	020082	TRANS PAD RGS1 10037	2
	020058	PLUG PLASTEX 297-000241-00-0101	2
	020271	COMP ENCAPSULATING MYGLASS #4 BLK	2

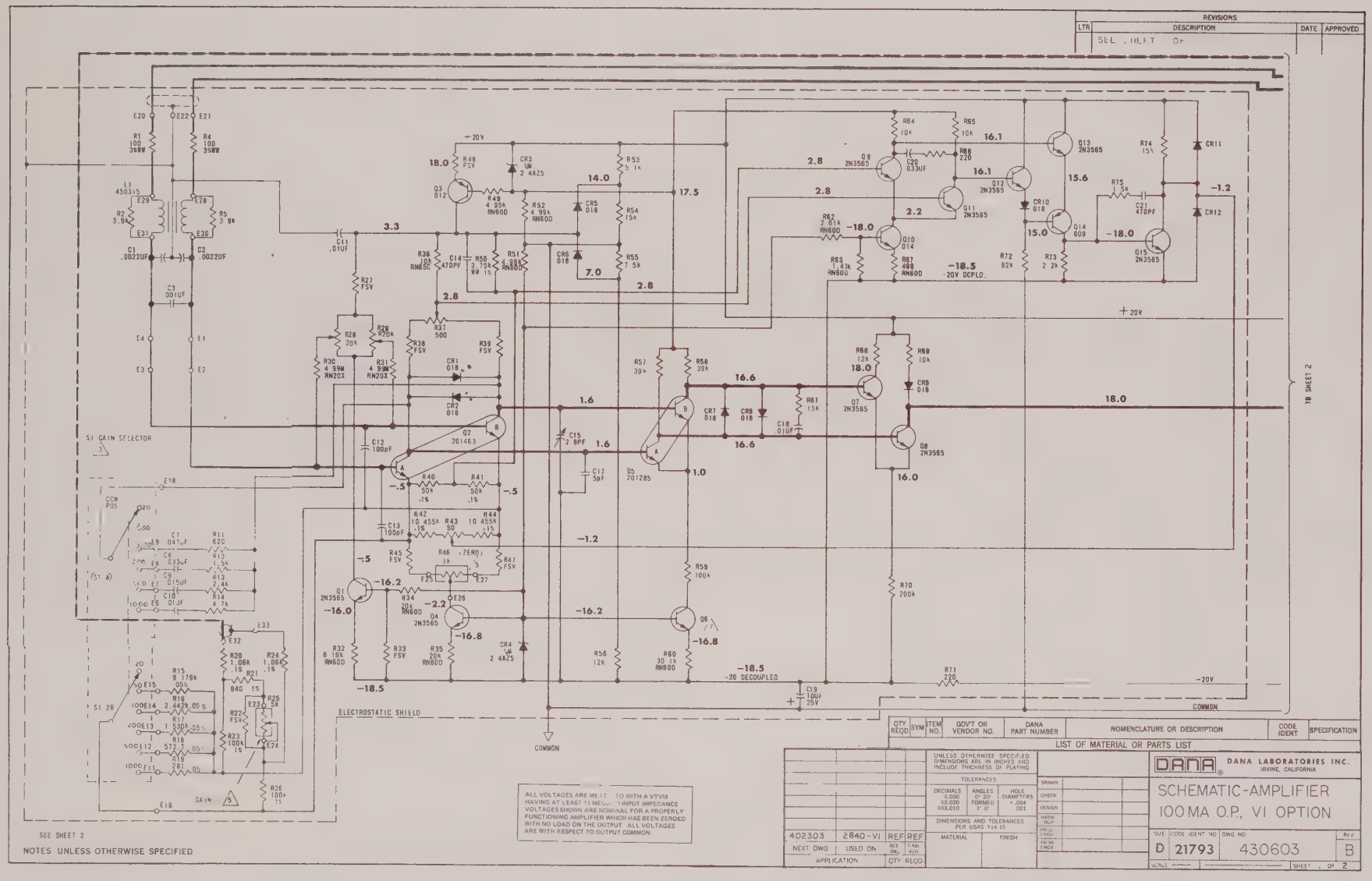
NOTE UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PCB ASSY —
MODEL 2820 V1

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402939	C

SCALE NONE WT. SHEET 5 OF 5



NOTES UNLESS OTHERWISE SPECIFIED

ALL VOLTAGES ARE MEASURED WITH A VTVM HAVING AT LEAST 11 MEGOHM INPUT IMPEDANCE VOLTAGES SHOWN ARE NOMINAL FOR A PROPERLY FUNCTIONING AMPLIFIER WHICH HAS BEEN ZEROED WITH NO LOAD ON THE OUTPUT. ALL VOLTAGES ARE WITH RESPECT TO OUTPUT COMMON.

LIST OF MATERIAL OR PARTS LIST

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

402303	2840-VI	REF	REF	
NEXT DWG	USED ON	NEXT DWG	THIS ASSY	
APPLICATION		QTY REQD		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X.020	0° 30'	+.004
XX.020	FORMED 1° 0'	-.001
XXX.010		

DIMENSIONS AND TOLERANCES PER USAS Y14.5

MATERIAL | FINISH

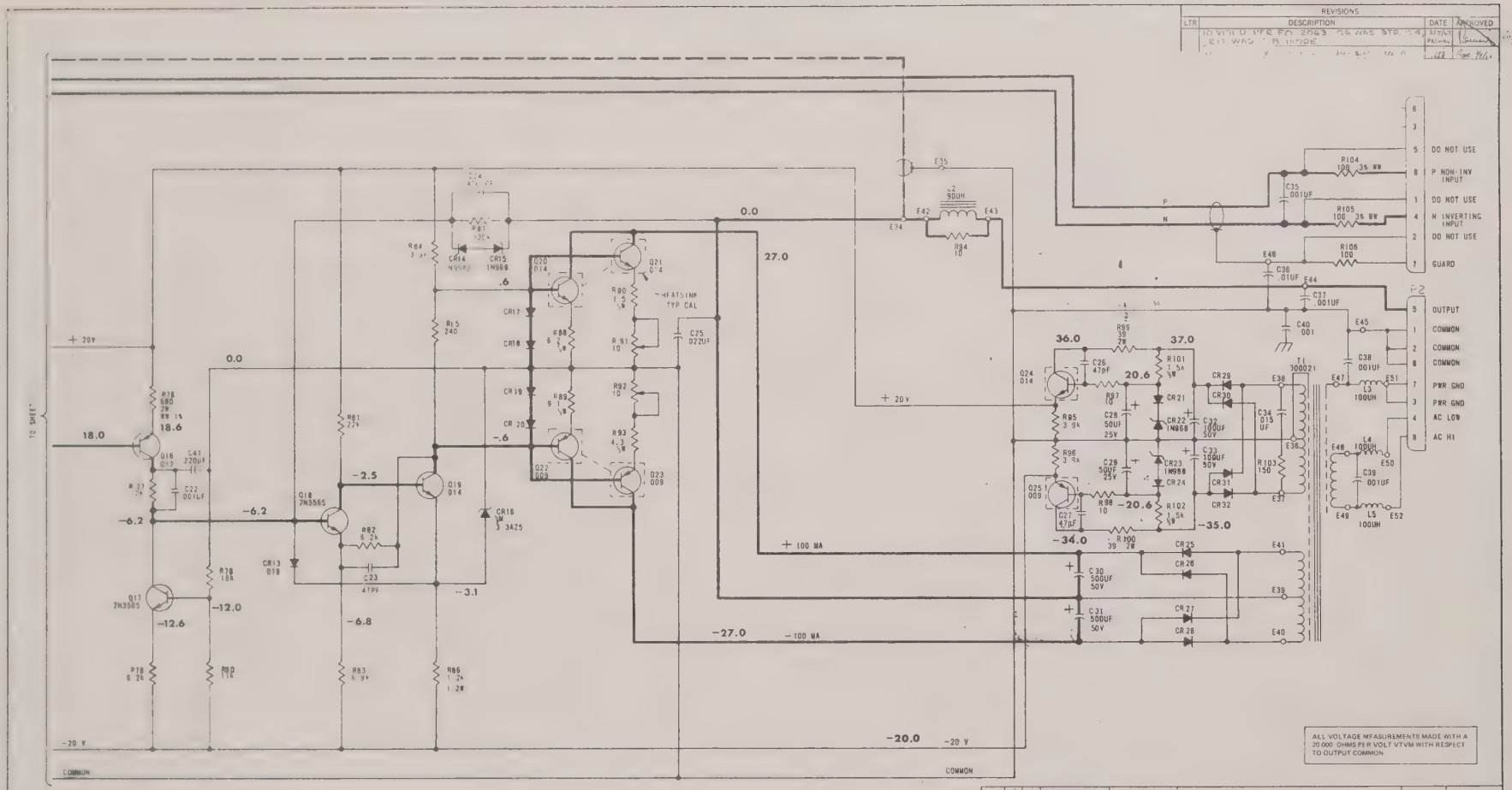
DRAWN | CHECK | DESIGN | MATERIAL ENGR | PROJ ENGR | PROD ENGR

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC-AMPLIFIER 100 MA O.P., VI OPTION

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	430603	B

SCALE — SHEET 1 OF 2



QTY REQD	SYM	ITEM NO.	GOVT OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

4 HIGHEST REFERENCE DESIGNATORS USED C41 CR32, L5 Q25, R108

3 REFERENCE C16 NOT USED

2 ALL RESISTORS ARE IN OHMS ± 5% CARBON

1 ALL DIODES ARE SD4'S

NOTES UNLESS OTHERWISE SPECIFIED

⚠1 TRANSISTOR Q8 IS A SELECTED Q14 P/N 200078

⚠2 E NUMBERS DENOTE EYELETS AND CORRESPOND TO POINTS ON PC BOARD SEE ASSY DRGS # 402305 (BASIC 9RD ASSY) AND 402304 (BRD ASSY W OPTION ADDED)

⚠5 R25(GAIN) R46(ZERO) & S1(GAIN SELECTOR) ARE FRONT PANEL ADJUSTMENT

402303	2840-V1	REF	REF
NEXT DWG	USED ON	NEXT DWG	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMAL X ±.030, XX ±.020, XXX ±.010 ANGLE ± FORMED 1° 0' HOLE DIAMETERS + .004 - .001

DIMENSIONS AND TOLERANCES PER USAS Y14.5

MATERIAL FINISH

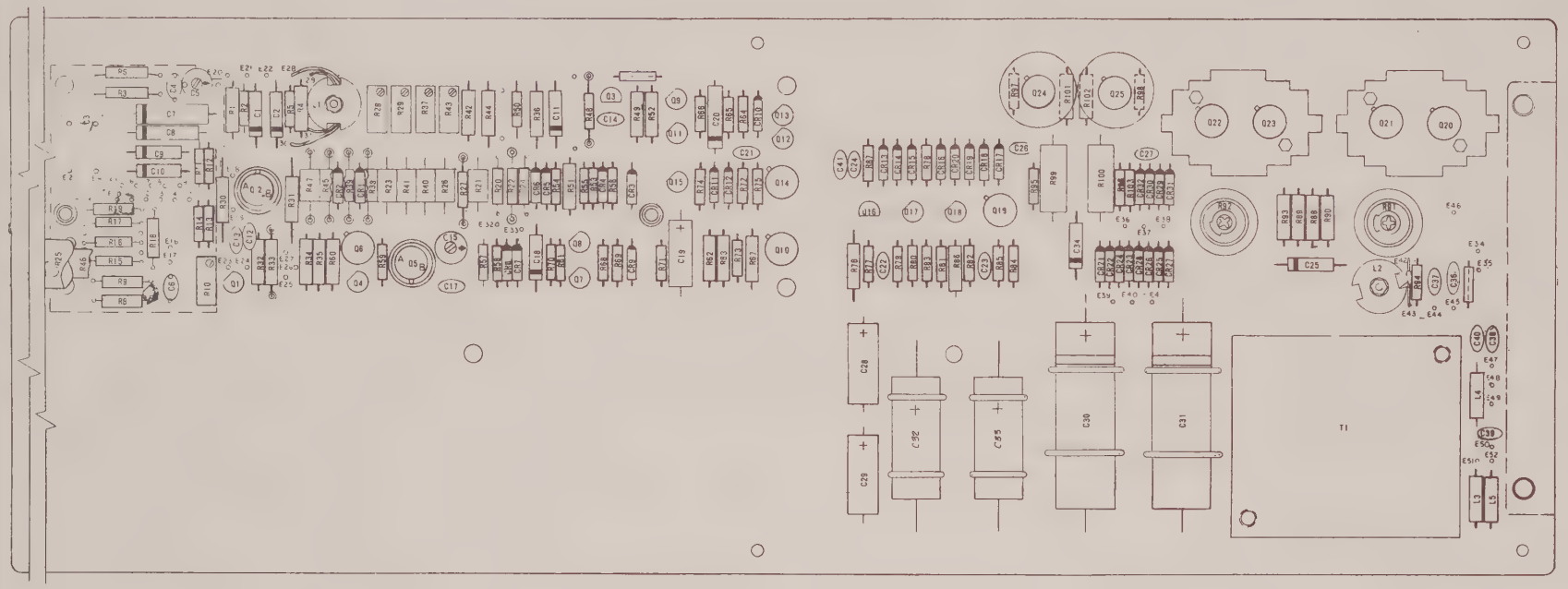
DRAWN CHECK DESIGN MECH ENGR PROJ ENGR PROD ENGR

DANA LABORATORIES INC. IRVINE, CALIFORNIA

SCHEMATIC - AMPLIFIER 100 MA O.P., V1 OPTION

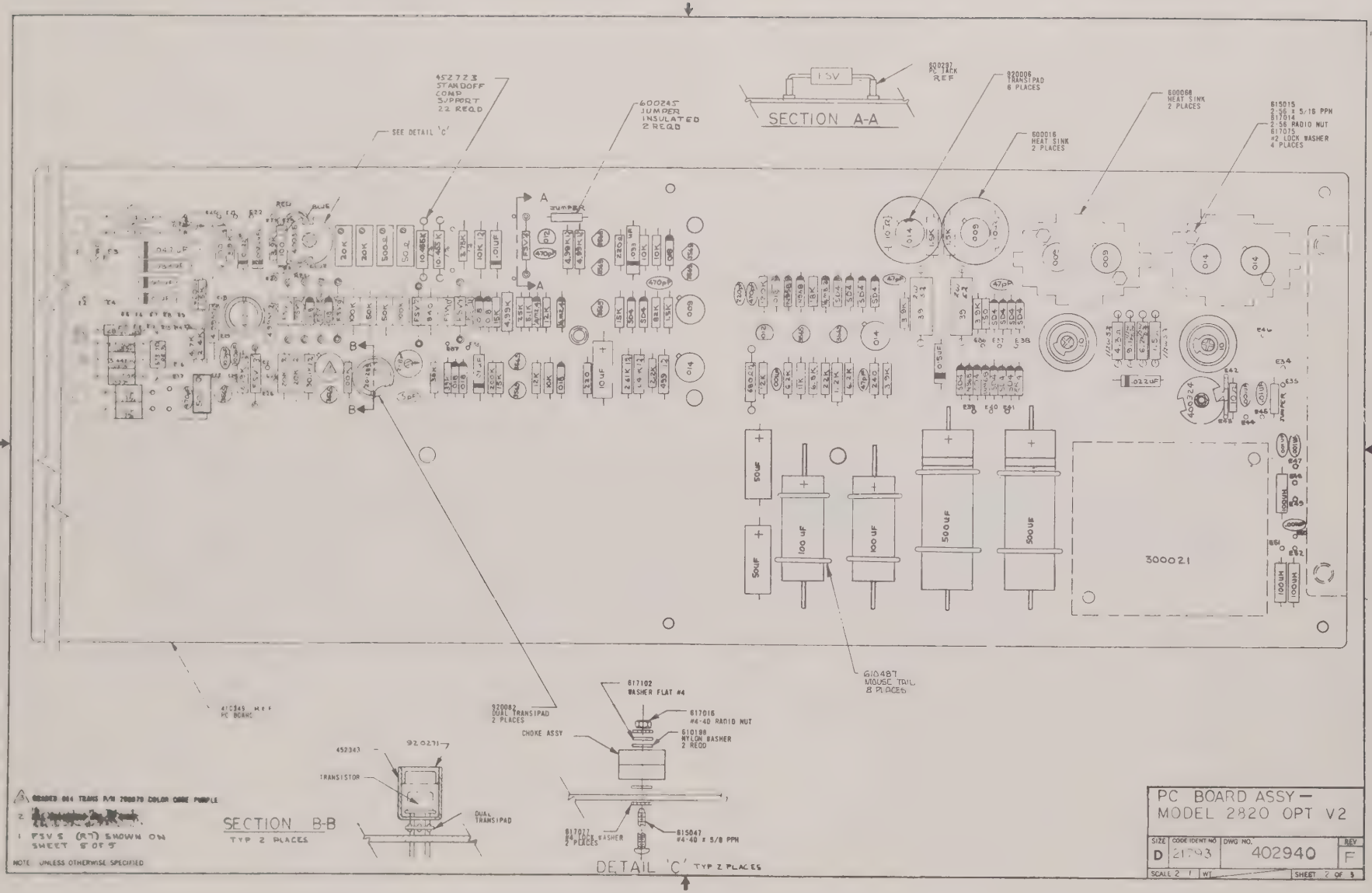
SIZE	CODE IDENT NO	DWG NO	REV
D	21793	430603	B

SCALE — SHEET 2 OF 2



NOTE. UNLESS OTHERWISE SPEC FIED

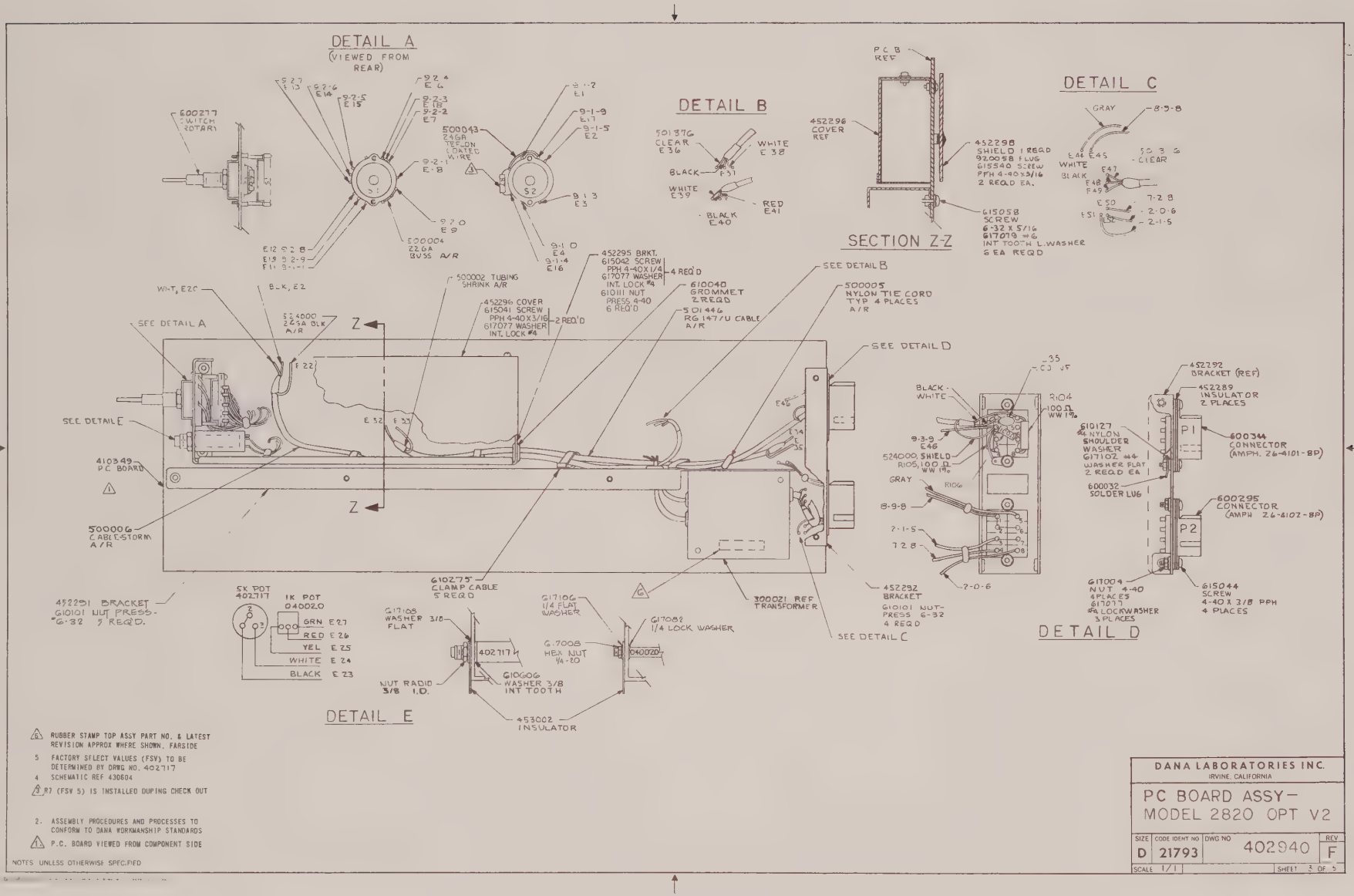
DANA LABORATORIES INC. IRVINE, CALIFORNIA			
P. C. BOARD ASSY— MODEL 2820 OPT V2			
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402940	F
SCALE 2 / 1	WT.	SHEET 1 OF 5	



PC BOARD ASSY —
MODEL 2820 OPT V2

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	402940	F

SCALE 2 / 1 | WT | SHEET 2 OF 5



⚠6 RUBBER STAMP TOP ASSY PART NO. & LATEST REVISION APPROX WHERE SHOWN. FARSIDE

5 FACTORY SELECT VALUES (FSV) TO BE DETERMINED BY DRWG NO. 402717

4 SCHEMATIC REF 430604

⚠3 R7 (FSV 5) IS INSTALLED DURING CHECK OUT

2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

⚠1 P.C. BOARD VIEWED FROM COMPONENT SIDE

NOTES UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASSY—
MODEL 2820 OPT V2

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	402940	F

SCALE 1/1 SHEET 3 OF 5

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C1	121092	0022UF 100V	2
C2	121092	0022UF 100V	REF
C3	101174	001UF DISC	7
C4	100006	10pF DISC	2
C5	130004	2-8pF VARIABLE	2
C6	101641	470pF DISC	4
C7	121083	047UF/100V	1
C8	121081	033UF 100V	2
C9	121086	015UF 100V	2
C10	121088	01UF 100V	3
C11	121088	01UF 100V	REF
C12	101145	100pF DISC	2
C13	101145	100pF DISC	REF
C14	101641	470pF DISC	REF
C15	130004	2-8pF VARIABLE	REF
C16		NOT USED	
C17	100009	5pF DISC	REF
[illegible]	121088	01UF 100V	REF
[illegible]	111262	10UF/25V	1
C20	121081	033UF 100V	REF
C21	101641	470pF DISC	REF
C22	101174	001UF DISC	REF
C23	101182	47pF DISC	3
C24	101641	470pF DISC	REF
C25	121468	022UF-100V	1
C26	101182	47pF DISC	REF
C27	101182	47pF DISC	REF
C28	110060	50UF/25V	2
[illegible]	[illegible]	[illegible]	[illegible]
C30	110062	500UF/50V	2
C31	110062	500UF/50V	REF
C32	110061	100UF/50V	2

REF DES OR ITEM	P/N	DESCRIPTION	QTY
L1	400315	RF CHOKE	1
L2	400324	90UH	1
L3	310033	100UH	3
L4	310033	100UH	REF
L5	310033	100UH	REF
Q1	200043	2N3565	11
Q2	402717	FSV ASSY	REF
Q3	200022	012	2
Q4	200043	2N3565	REF
Q5	201285	DUAL STAGE DUAL	1
Q6	200078	014 (SELECT)	1
Q7	200043	2N3565	REF
Q8	200043	2N3565	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R12	000152	1 5k	2
R13	000242	2.4k	1
R14	000472	4.7k	1
R15	070424	8 178k .05% WW 1	1
R16	074423	3 442k .05% WW 1	1
R17	070422	1 530k .05% WW 1	1
R18	070421	573.7Ω .05% WW 1	1
R19	070420	281Ω .05% WW 1	1
R20	402717	FSV. ASSY	REF
R21	020086	840 OHMS WW 1%	1
R22	402717	FSV ASSY	REF
R23	020078	100k WW .1%	2
R24	402717	FSV ASSY	REF
R25	402717	FSV. ASSY	REF
R26	020079	10Mk WW 1%	REF
R27	402717	FSV ASSY	REF
R28	040092	20k POT	2
R29	040092	20k POT	REF
R30	011178	4 99Ω RN60K	2
R31	011178	4 99Ω RN60K	REF
R32	010130	6.19k RN60D	1
R33	402717	FSV ASSY	REF
R34	010059	20k RN60D	2
R35	010059	20k RN60D	REF
R36	010110	10k RN65C	1
R37	040093	50k OHMS POT	REF
R38	402717	FSV. ASSY	REF
R39	402717	FSV. ASSY	REF
R40	020078	50k WW .1%	2
R41	020078	50k WW 1%	REF
R42	020425	10 455k 1%E20CF	2
R43	040100	50 OHMS POT	1
R44	020425	10 499k 1%E20CF	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R78	000622	6.2k	2
R80	000113	11k	1
R81	000223	22k	1
R82	000627	6.2k	REF
R83	000602	6.8k	1
R84	000392	3.9k	REF
R85	000241	240 OHMS	1
R86	001469	1.2k 1/2W 5%	1
R87	000124	120k	1
R88	001740	6 2 OHMS 1/2W 5%	1
R89	001741	8 1 OHMS 1/2W 5%	1
R90	001738	1 5 OHMS 1/2W 5%	1
R91	041478	10Ω POT(CTS)	2
R92	041478	10oPOT(CTS)	REF
R93	001739	4.3 OHMS 1/2W 5%	1
R94	000100	10 OHMS	3
R95	000392	3.9k	REF
R96	000392	3 9k	REF
R97	000100	10 OHMS	REF
R98	000100	10 OHMS	REF
R99	030003	30 OHMS 2W 5%	2
R100	030003	30 OHMS 2W 5%	REF
R101	001602	1 5k 1/2W 5%	2
R102	001602	1.5k 1/2W 5%	REF
R103	000151	150 OHMS	1
R104	020106	100 OHMS WW 3%	REF
R105	020106	100 OHMS WW 3%	REF
R106	000101	100 OHMS	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R45	402717	FSV.ASSY	REF
R46	040020	1k POT	1
R47	402717	FSV. ASSY	REF
R48	402717	FSV. ASSY	REF
R49	010020	4 99k RN60D	3
R50	020104	3.75k WW 1%	1
R51	010020	4 88k RN60D	REF
R52	010020	4 88k RN60D	REF
R53	000512	5.1k	1
R54	000153	15k	3
R55	000752	7.5k	1
R56	000123	12k	3
R57	000393	39k	2
R58	000393	39k	REF
R59	000104	100k	1
R60	010018	30 1K RN60D	1
R61	000153	15k	REF
R62	011334	2 81k RN60D	1
R63	010068	1.40k RN60D	1
R64	000103	10k	3
R65	000103	10k	REF
R66	000221	220 OHMS	2
R67	010027	499 OHMS RN60D	1
R68	000123	12k	REF
R69	000103	10k	REF
R70	000204	200k	1
R71	000221	220 OHMS	REF
R72	000823	82k	1
R73	000222	2.2k	1
R74	000153	15k	REF
R75	000132	1 5k	REF
R76	020110	680k 2W 1%	1
R77	000123	12k	REF
R78	000103	10k	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
T1	300021	TRANSFORMER	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	402717	FSV ASSEMBLY	1
	410348	PCB AMPL 100N OP	1
	420347	PCB ARTWORK	REF
	430804	SCHEMATIC	REF
	452280	INSULATOR	2
	452281	BRACKET-SUPPORT	1
	452282	BRACKET-CONN MTG	1
	452295	BRACKET-ELEC SHIELD	1
	452288	COVER ELEC SHIELD	1
	452288	SHIELD ELECSTAT	1
	452343	CASE-MODIFIED 920256 NY GLASS #M5	2
	453002	INSL POT MTG	1
	452723	STANDOFF COMP	22
	500002	TUBING SHRINK .153 I.D.	A/R
	500004	WIRE-BUSS 22GA TINNED	A/R
	500005	NYLON TIE CORD	A/R
	500008	CABLE STORM B24 18/38H S2V	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	500843	WIRE-24GA TEFLON COATED	A/R
	501376	TEFLON TUBING 24GA	A/R
	501448	CABLE RG 174/U 1 COND. SHIELD	A/R
	524000	WIRE 24GA STR. 0 COLOR	A/R
	524206	WIRE 24GA STR. 2-0-8 COLOR	A/R
	524215	WIRE 24GA STR 2-1-5 COLOR	A/R
	524728	WIRE 24GA STR 7-2-8 COLOR	A/R
	524988	WIRE 24GA STR GRAY COLOR	A/R
	524998	WIRE 24GA STR 9-9-8 COLOR	A/R
	524910	WIRE 24GA STR 9-1-0 COLOR	A/R
	524812	WIRE 24GA STR 9-1-2 COLOR	A/R
	524813	WIRE 24GA STR 9-1-3 COLOR	A/R
	524814	WIRE 24GA STR 9-1-4 COLOR	A/R
	524815	WIRE 24GA STR 9-1-5 COLOR	A/R
	524816	WIRE 24GA STR 9-1-6 COLOR	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	524820	WIRE 24GA STR 9-2-0 COLOR	A/R
	524821	WIRE 24GA STR 9-2-1 COLOR	A/R
	524822	WIRE 24GA STR 9-2-2 COLOR	A/R
	524823	WIRE 24GA STR 9-2-3 COLOR	A/R
	524824	WIRE 24GA STR 9-2-4 COLOR	A/R
	524825	WIRE 24GA STR 9-2-5 COLOR	A/R
	524826	WIRE 24GA STR 9-2-6 COLOR	A/R
	524827	WIRE 24GA STR 9-2-7 COLOR	A/R
	524828	WIRE 24GA STR 9-2-8 COLOR	A/R
	524829	WIRE 24GA STR 9-2-9 COLOR	A/R
	524830	WIRE 24GA STR 9-3-0 COLOR	A/R
	524831	WIRE 24GA STR 9-3-1 COLOR	A/R
	524832	WIRE 24GA STR 9-3-2 COLOR	A/R
	524834	WIRE 24GA STR 9-3-4 COLOR	A/R
	524835	WIRE 24GA STR 9-3 5 COLOR	A/R
	524836	WIRE 24GA STR 9-3-6 COLOR	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	524839	WIRE 24GA STR 9-3-9 COLOR	A/R
	524900	WIRE 24GA STR 9-0-0 COLOR	A/R
	800018	HEATSHK IERC TXBF-032-0250	2
	800082	LUG SOLDER SMITH 1418-4	1
	800086	HEAT DISS IERC LP583B	2
	800245	JUMPER-INSULATED	2
	800277	SWITCH-ROTARY	1
	800285	PLUG-CONN 8 PIN AMPH 28-4102-8P	1
	800287	CONN PC JACK	10
	800344	CONN 8 PIN AMPH 26-4101-8P	1
	610487	TIE STRAP MOUSE TAIL	8
	610040	GROMMET-RUBBER 1/4 I D	2
	810101	NUT-PRESS 8-32 PEM S-832-1	8
	810111	NUT PRESS 4-40 PEM S-440-1	8
	810127	#4 SHOULDER WASHER NYLON	2
	810180	#4 NYLON WASHER	4
	810686	3/8 LOCK WASHER	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	810252	STDOFF-SW 4 40 X 1/8 LG 1/4O .08 MTG	2
	810275	CLAMP-CABLE PL BUDWIG 3-4-1	5
	815015	SCREW PPH 2-56 X 5/16	4
	815041	SCREW PPH 4-40 X 3/16	2
	815042	SCREW PPH 4-40 X 1/4 LG	4
	815044	SCREW PPH 4-40 X 3/8 LG	4
	815047	SCREW PPH 4-40 X 5/8 LG	2
	815058	SCREW PPH 8-32 X 5/18 LG	8
	815540	SCREW FLAT HD 4-40 X 3/16 LG	2
	617008	NUT HEX 1/4 x 40	1
	617106	1/4 FLAT WASHER	1
	617108	3/8 FLAT WASHER	1
	617082	1/4 FLAT WASHER	1
	617004	NUT-HEX 4-40	4
	617014	NUT-HEX 2-56 RADIO	4
	913018	NUT-HEX 4-40 RADIO	2
	617075	INT TH LOCK - WASHER #2	4
	617077	INT TH LOCK - WASHER #4	13
	617078	INT TH LOCK - WASHER #8	8
	617102	WASHER-FLAT #4	4

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	920008	TRANS PAD LRG	8
	920010	SOLDER-BAR 60/37	A/R
	920026	SOLDER-WIRE	A/R
	920082	TRANS PAD ROSS 10037	2
	920058	PLUG PLASTEX 207-090241-00-0101	2
	920271	CUP ENCAPSULATING NYGLASS #4 BLK	2

REF DES OR ITEM	P/N	DESCRIPTION	QTY
CR1	211083	018	8
CR2	211083	018	REF
CR3	221177	1/4W2 4AZ5	2
CR4	221177	1/4W2 4AZ5	REF
CR5	211083	018	REF
CR6	211083	018	REF
CR7	211083	018	REF
CR8	211083	018	REF
[illegible]	211083	018	REF
[illegible]	211083	018	REF
[illegible]	210004	SD4	16
[illegible]	210004	SD4	REF
[illegible]	211083	018	REF
CR14	229012	1N6588	1
[illegible]	229011	1N6080	3
CR16	220031	1/4W3 3AZ5	1
[illegible]	210004	SD4	REF
[illegible]	210004	SD4	REF
[illegible]	210004	SD4	REF
[illegible]	210004	SD4	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R1	020106	100 OHMS WW 3%	4
R2	000302	3 9k	5
R3	010111	1W 1%MFRN65C	2
R4	020106	100 OHMS WW 3%	REF
R5	000302	3 9k	REF
R6	010111	1W 1%MFRN65C	REF
R7	402717	FSV ASSY	REF
R8	020087	10k WW 1%	2
R9	020097	1Ωk WW 1%	REF
R10	040093	500 OHM POT	2
R11	000021	020 OHMS	1

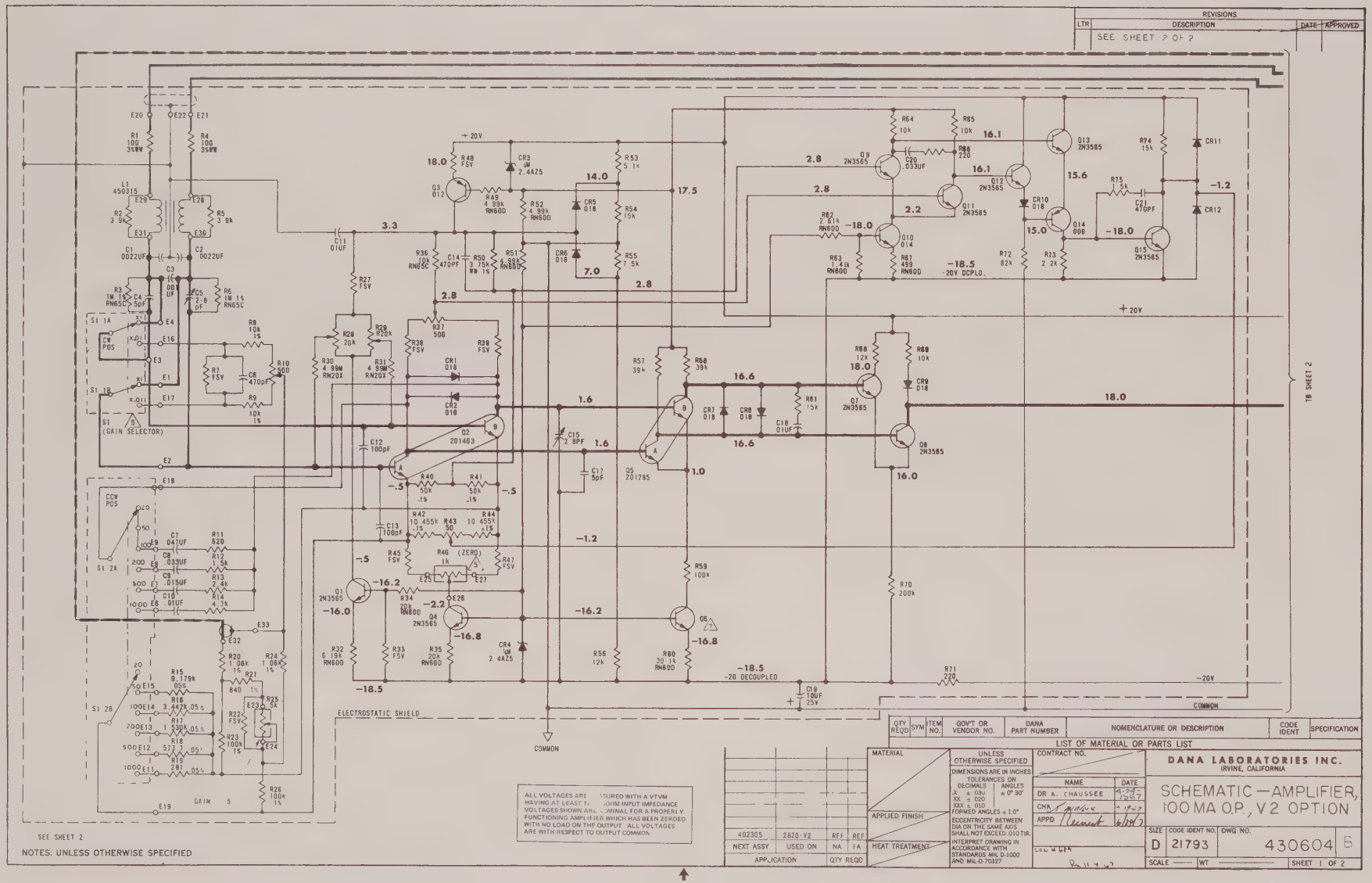
NOTE UNLESS OTHERWISE SPECIFIED

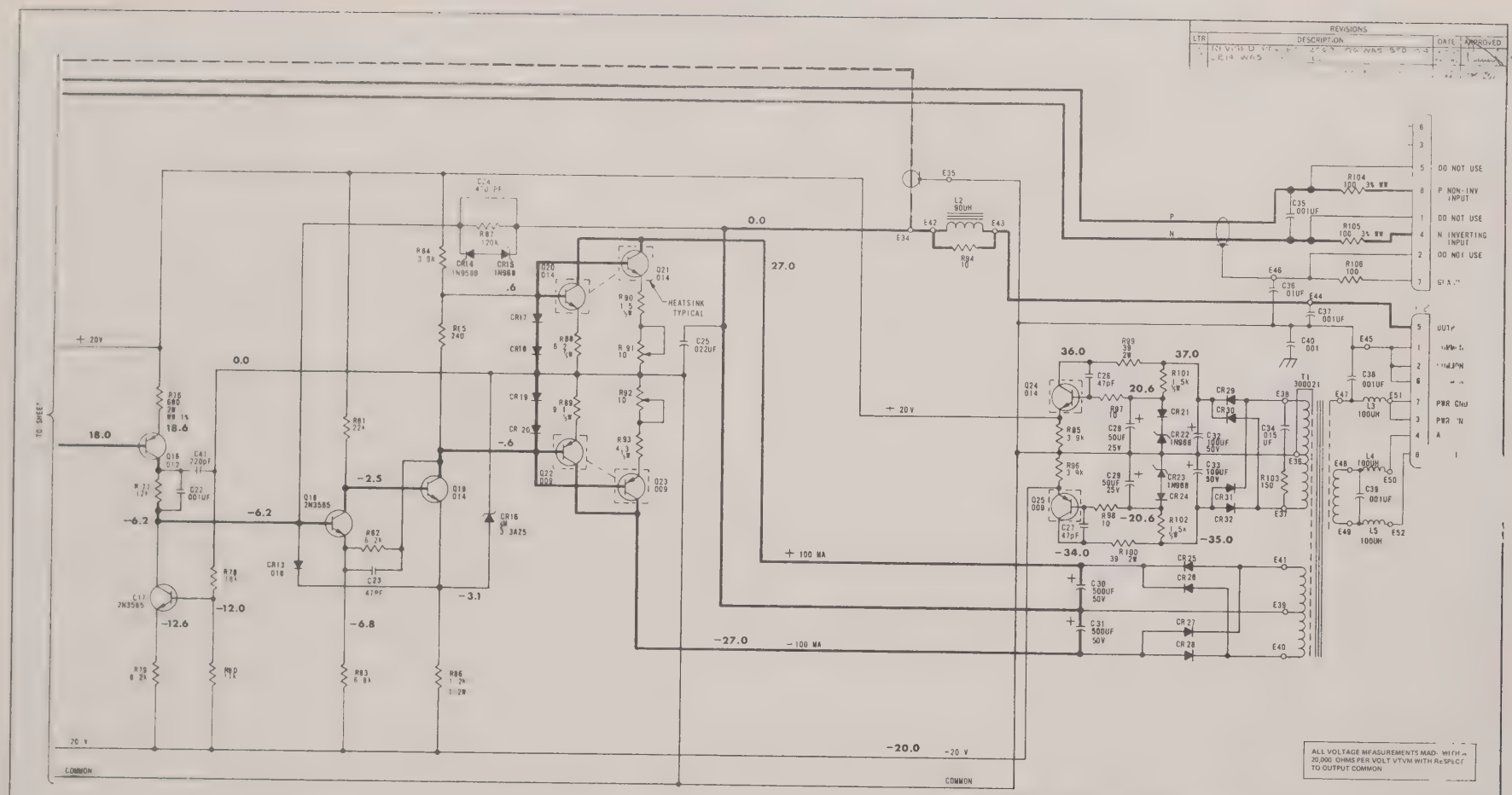
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PCB ASSY —
MODEL 2820 OPT V2

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	402940	F

SCALE NONE WT SHEET 5 OF 5


REVISIONS
LTR
DESCRIPTION
DATE
APPROVED
SEE SHEET 2 OF 2
+20V
-20V
COMMON
ELECTROSTATIC SHIELD
TO SHEET 2
S1 (GAIN SELECTOR)
CW POS
CCW POS
GAIN 5
-18.5 -20 DECOUPLED
-18.5 -20V DCPLD.
ALL VOLTAGES ARE MEASURED WITH A VTVM HAVING AT LEAST 11 MEGOHM INPUT IMPEDANCE VOLTAGES SHOWN ARE NOMINAL FOR A PROPERLY FUNCTIONING AMPLIFIER WHICH HAS BEEN ZEROED WITH NO LOAD ON THE OUTPUT. ALL VOLTAGES ARE WITH RESPECT TO OUTPUT COMMON.
SEE SHEET 2
NOTES: UNLESS OTHERWISE SPECIFIED
QTY REQD
SYM
ITEM NO.
GOV'T OR VENDOR NO.
DANA PART NUMBER
NOMENCLATURE OR DESCRIPTION
CODE IDENT
SPECIFICATION
LIST OF MATERIAL OR PARTS LIST
402305
2820-V2
REF
NEXT ASSY
USED ON
NA
FA
APPLICATION
QTY REQD
MATERIAL
APPLIED FINISH
HEAT TREATMENT
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ANGLES
X ± .030 ± 0° 30'
XX ± .020
XXX ± .010
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL D-1000 AND MIL-D-70327
CONTRACT NO.
NAME
DATE
DR A. CHAUSSEE 4-29-67
CHK 4-29-67
APPD 4-29-67
DANA LABORATORIES INC.
IRVINE, CALIFORNIA
SCHEMATIC — AMPLIFIER, 100 MA O.P., V2 OPTION
SIZE D
CODE IDENT NO. 21793
DWG NO. 430604
REV B
SCALE
WT
SHEET 1 OF 2



QTY REQD	SYM	ITEM NO	GOVT OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

4 HIGHEST REFERENCE DESIGNATORS USED C41 CR32 L5 Q25 R108

3 REFERENCE C18 NOT USED

2 ALL RESISTORS ARE IN OHMS 1/4W ± 5% CARBON
ALL DIODES ARE SD4'S

NOTES UNLESS OTHERWISE SPECIFIED

1 TRANSISTOR Q6 IS A SELECTED 014 P/N 200078

6 E NUMBERS DENOTE EYELETS AND CORRESPOND TO POINTS ON PC BOARD SEE ASSY DWGS # 402305 (BASIC 3RD ASSY) AND 402304 (3RD ASSY # OPTION ADDED)

5 R25(GAIN) R46(ZERO) & S1(GAIN SELECTOR) ARE FRONT PANEL ADJUSTMENT

402305	2820-V2	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

MATERIAL
APPLIED FINISH
HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ANGLES
X ± .030 ± 0° 30'
XX ± .020
XXX ± .010
FORMED ANGLES ± 1°
ECCENTRICITY BETWEEN DIA ON THIS SAME AXIS SHALL NOT EXCEED .010 T.I.R
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL D-1000 AND MIL D-70327

CONTRACT NO.

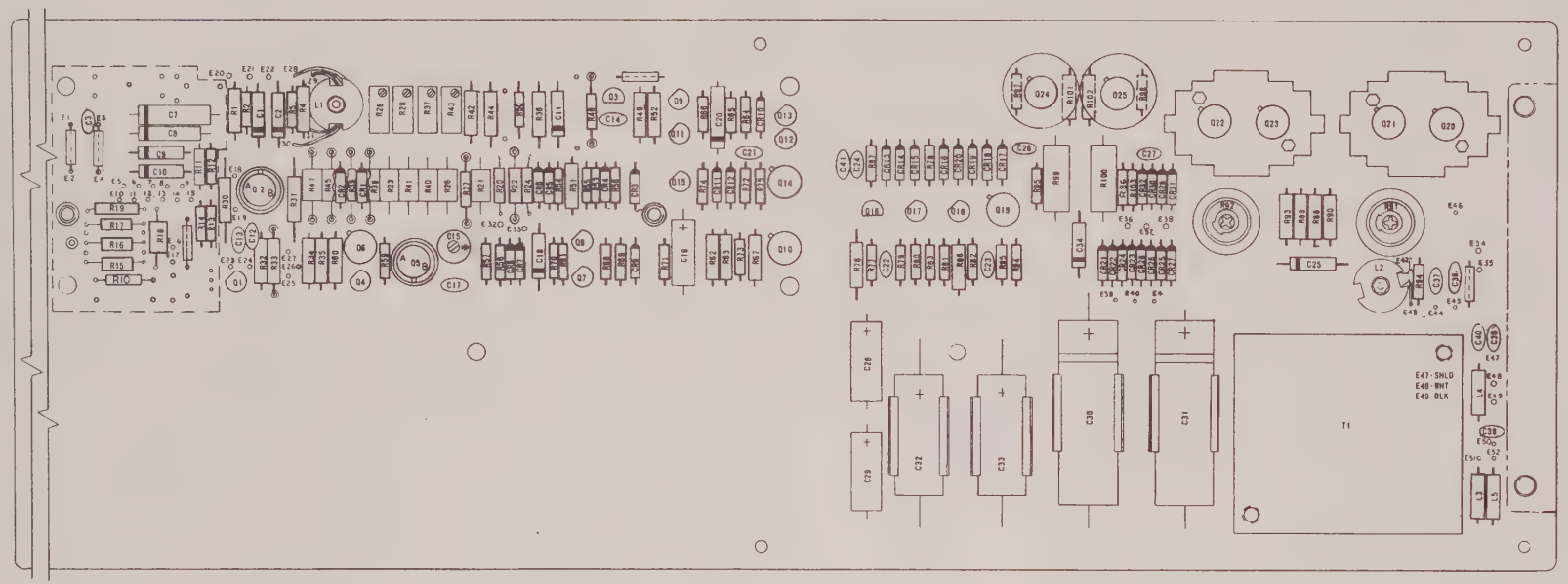
	NAME	DATE
DR	[illegible]	4-24-1967
CHK	[illegible]	5-9-67
APPD	[illegible]	6/9/67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC-AMPLIFIER 100MA O.P., V2 OPTION

SIZE	CODE IDENT NO	DWG NO.
D	21793	430604

SCALE — WT — SHEET 1 OF



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P N	ITEM NO

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS .X ±.03, .XX ±.010, .XXX ±.005; ANGLES 0° 30'; FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN R Prahal OCT 9 68

CHECK

COG ENGR

PROJ ENGR

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P. C. BOARD ASSY—
MODEL 2820 OPT V3

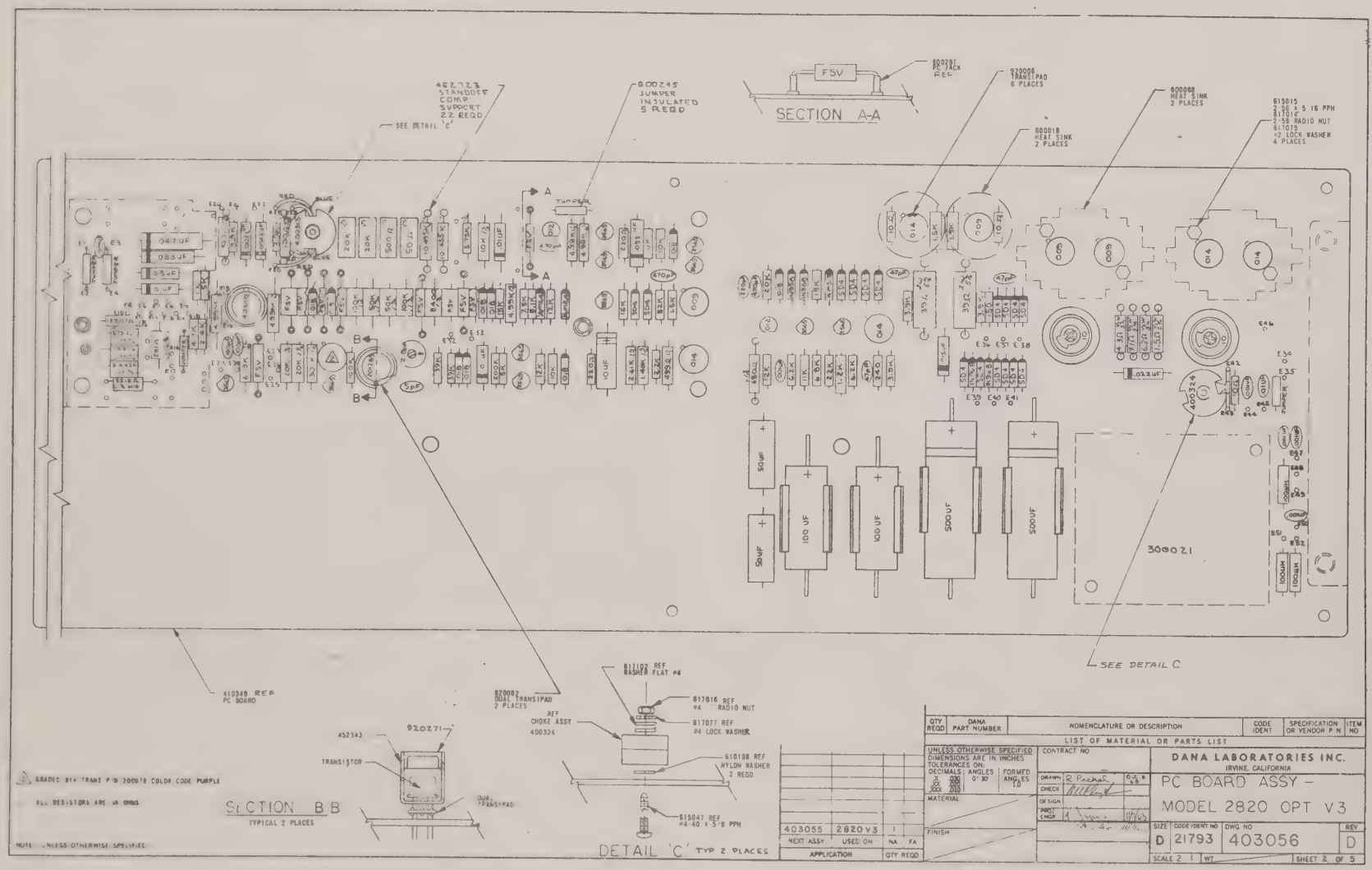
403055	2820-V3	1	1
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403056	D

SCALE 2/1 | WT | SHEET 1 OF 5

1. COMPONENTS NOT SHOWN ON THIS SHEET ARE SHOWN ON SHEET 3 OF 5 (R25, R46, R104, R105, R106 AND C35).

NOTE UNLESS OTHERWISE SPECIFIED



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P N	ITEM NO
		LIST OF MATERIAL OR PARTS LIST			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS | ANGLES | FORMED ANGLES
X .000 ± 0° 30' ± 1.0
XX .000 ± .010
XXX .000 ± .005
MATERIAL
FINISH

CONTRACT NO

DRAWN R Pachal 6-4-71
CHECK
DESIGN
PROJ ENGR

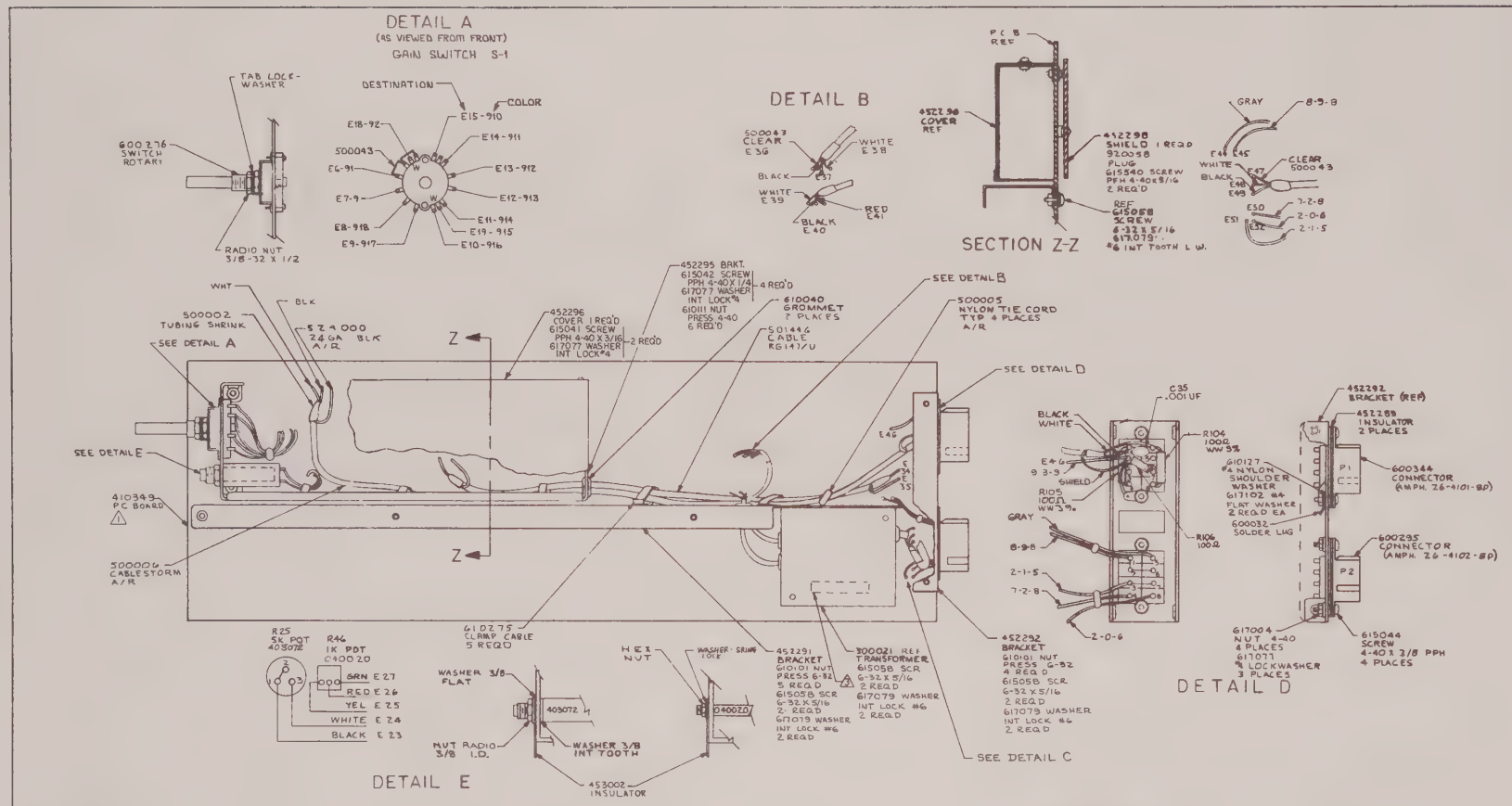
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASSY - MODEL 2820 OPT V3

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403056	D

SCALE 2 / 1 WT SHEET 2 OF 5

403055	2820 V3	1	
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	



5. FACTORY SELECT VALUES (FSV) TO BE DETERMINED BY DRWG NO. 403072
4. SCHEMATIC REFERENCE 430802
1. RUBBER STAMP ASSY NO. AND LATEST REVISION LETTER APPROX WHERE SHOWN (FARSIDE).
2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS
1. PC BOARD VIEWED FROM COMPONENT SIDE

NOTES UNLESS OTHERWISE SPECIFIED

NEXT DWG	USED ON	REV LTR	FINAL ASSY
403055	2820 V3	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X .030, XX .020, XXX .010; ANGLES 0 30', 1 0'; HOLE DIAMETERS FORMED +.004 -.001
MATERIAL
FINISH

DRAWN	R Pickard	Aug 9 68
CHECK		
DESIGN		
MECH ENGR		
PROJ ENGR		

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASSY-
MODEL 2820 OPT V3

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403056	D

SCALE 1/1 SHEET 3 OF 5

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C1	121092	.0022UF 100V	2
C2	121092	.0022UF 100V	REF
C3	101174	.001UF DISC	1
C4		NOT USED	
C5		NOT USED	
C6		NOT USED	
C7	121083	.047UF 100V	
C8	121081	.033UF 100V	2
C9	121080	.015UF 100V	2
C10	121088	.01UF 100V	3
C11	121088	.01UF 100V	REF
C12	101145	100pF DISC	2
C13	101145	100pF DISC	REF
C14	101141	470pF DISC	3
C15	190004	2-8pF VARIABLE	1
C16		NOT USED	
C17	100009	5pF DISC	1
C18	121086	.01UF 100V	REF
C19	111282	10UF/25V	1
C20	121091	.033UF/100V	REF
C21	101141	470pF DISC	REF
C22	101174	.001UF DISC	REF
C23	101182	47pF DISC	3
C24	101141	470pF DISC	REF
C25	121458	.022UF 100V	1
C26	101182	47pF DISC	REF
C27	101182	47pF DISC	REF
C28	110080	50UF/25V	2
C29	110080	50UF 25V	REF
C30	110062	500UF/50V	2
C31	110082	500UF/50V	REF
C32	110081	100UF/50V	2
C33	110081	100UF/50V	REF
C34	121088	.01UF/100V	REF
C35	101174	.001UF DISC	REF
C36	100017	.01UF DISC	1
C37	101174	.001UF DISC	REF
C38	101174	.001UF DISC	REF
C39	101174	.001UF DISC	REF
C40	101174	.001UF DISC	REF
C41	101178	220pF DISC	1
CR1	211083	D18	8
CR2	211083	D18	REF
CR3	220030	1.4W 4A2S	2
CR4	220030	1.4W 4A2S	REF
CR5	211083	D18	REF
CR6	211083	D18	REF
CR7	211083	D18	REF
CR8	211083	D18	REF
CR9	211083	D18	REF
CR10	211083	D18	REF
CR11	210004	SD4	16
CR12	210004	SD4	REF
CR13	211083	D18	REF
CR14	220012	1N5818	1
CR15	220011	1N9888	3
CR16	220031	1/4W3 3AZ5	1
CR17	210004	SD4	REF
CR18	[illegible]	SD4	REF
CR19	210004	SD4	REF
CR20	210004	SD4	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
CR21	210004	SD4	REF
CR22	220011	1N9888	REF
CR23	220011	1N9888	REF
CR24	210004	SD4	REF
CR25	210004	SD4	REF
CR26	210004	SD4	REF
CR27	210004	SD4	REF
CR28	210004	SD4	REF
CR29	210004	SD4	REF
CR30	210004	SD4	REF
CR31	210004	SD4	REF
CR32	210004	SD4	REF
L1	400315	RF CHOKE	1
L2	400224	[illegible]	1
L3	310033	100UH	3
L4	310033	100UH	REF
L5	310033	180UH	REF
Q1	200043	2N3565	11
Q2	403072	FSV ASSY	REF
Q3	200022	D12	2
Q4	200043	2N3565	REF
Q5	201285	2ND STAGE DUAL	1
Q6	200078	D14 (SELECT)	1
Q7	200043	2N3565	REF
Q8	200843	2N3565	REF
Q9	200043	[illegible]	REF
Q10	200035	D14	5
Q11	200043	2N3565	REF
Q12	200843	2N3565	REF
Q13	200043	2N3565	REF
Q14	200011	Q09	4
Q15	200043	2N3565	REF
Q16	200022	D12	REF
Q17	200043	2N3565	REF
Q18	200843	2N3565	REF
Q19	200035	D14	REF
Q20	200035	D14	REF
Q21	200035	D14	REF
Q22	200011	[illegible]	REF
Q23	200011	[illegible]	REF
Q24	200035	D14	REF
Q25	200011	Q09	REF
R1	020108	100 OHMS WW 3%	4
R2	000382	3 9k	5
R3		NOT USED	
R4	020108	100 OHMS WW 3%	REF
R5	000382	3 9k	REF
R6		NOT USED	
R7		NOT USED	
R8		NOT USED	
R9		NOT USED	
R10	020503	55.6 OHMS WW 1%	1
R11	000102	1k	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R12	000152	1 5k	2
R13	000242	2 4k	1
R14	000472	4 7k	1
R15	023568	15900 OHMS WW 1%	1
R16	020423	3 442k .05% WW	1
R17	020427	1 530k .05% WW	1
R18	020421	573.3Ω .05% WW	1
R19	020420	287Ω .05% WW	1
R20	403072	FSV ASSY	REF
R21	020086	840 OHMS WW 1%	1
R22	403072	FSV ASSY	REF
R23	020019	100k WW 1%	2
R24	403072	FSV ASSY	REF
R25	403072	FSV ASSY	REF
R26	020019	100k WW 1%	REF
R27	403072	FSV ASSY	REF
R28	040092	20k POT	2
R29	040092	20k POT	REF
R30	011178	4.99W RW28X	2
R31	011178	4.99W RW28X	REF
R32	010130	6.19k RN60D	1
R33	403072	FSV ASSY	REF
R34	010059	20k RN60D	2
R35	010058	20k RN60D	REF
R36	010110	10k RN65C	1
R37	040093	500 OHMS POT	1
R38	403072	FSV ASSY	REF
R39	403072	FSV ASSY	REF
R40	020078	50k WW 1%	2
R41	020078	50k WW 1%	REF
R42	020425	10 455k 1%W2DCF	2
R43	040108	50 OHMS POT	1
R44	020425	10 455k 1%W2DCF	REF
R45	403072	FSV ASSY	REF
R46	040020	1k POT	1
R47	403072	FSV ASSY	REF
R48	403072	FSV ASSY	REF
R49	010020	4.99k RN60D	3
R50	020104	3.75k WW 1%	1
R51	010020	4.99k RN60D	REF
R52	010020	4.99k RN60D	REF
R53	000512	5 1k	1
R54	000153	15k	3
R55	000752	7 5k	1
R56	000123	12k	3
R57	000393	39k	2
R58	000393	39k	REF
R59	000104	100k	1
R60	010019	30.1k RN60D	1
R61	000153	15k	REF
R62	011334	2 81k RN60D	1
R63	[illegible]	1 40k RN60D	1
R64	000103	10k	3
R65	000103	10k	REF
R66	009221	220 OHMS	2
R67	010027	499 OHMS RN60D	1
R68	000123	12k	REF
R69	000103	10k	REF
R70	000204	200k	1
R71	000221	220 OHMS	REF
R72	[illegible]	82k	1
R73	000222	2 2k	1
R74	000153	15k	REF
R75	000152	1 5k	REF
R76	020119	680Ω2 WW 1%	1
R77	000123	12k	REF
R78	000822	8 2k	2
R79	000113	11k	1
R81	000223	22k	1
R82	000822	8 2k	REF
R83	[illegible]	6 8k	1
R84	000392	3 9k	REF
R85	000241	240 OHMS	1
R86	001469	1 2k 1/2W 5%	1
R87	000174	120k	1
R88	001740	6 2 OHMS 1/2W 5%	1
R89	001741	9 1 OHMS 1/2W 5%	1
R90	001738	1 5 OHMS 1/2W 5%	1
R91	041476	10Ω POT(CTS)	2
R92	041476	10 POT (CTS)	REF
R93	001739	4 3 OHMS 1/2W 5%	1
R94	000100	10 OHMS	3
R95	000382	3 9k	REF
R96	000392	3 9k	REF
R97	000100	10 OHMS	REF
R98	000100	10 OHMS	REF
R99	030003	39 OHMS 2W 5%	2
R100	030003	39 OHMS 2W 5%	REF
R101	001682	1.5k 1/2W 5%	2
R102	001682	1.5k 1/2W 5%	REF
R103	000151	150 OHMS	1
R104	020106	100 OHMS WW 3%	REF
R105	020106	100 OHMS WW 3%	REF
R106	000101	100 OHMS	1
T1	300021	TRANSFORMER	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	403072	FSV ASSEMBLY	1
	410348	PCB AMPL 100W OP	1
	430502	SCHEMATIC	REF
	452293	INSULATOR	2
	452291	BRACKET-SUPPORT	1
	452292	BRACKET-CONN MTG	1
	452295	BRACKET-ELEC SHIELD	1
	452296	COVER ELEC SHIELD	1
	452289	SHIELD ELECSTAT	1
	452343	CASE-MODIFIED 920258 NY GLASS ons	2
	453002	INSL POT MTG	1
	452723	STANDOFF COMP .82	2
	452725	CLIP COMP 580 DIA MTG	2
	452726	CLIP COMP 800 DIA MTG	2
	500002	TUBING SHRINK 753 I D.	A/R
	500064	WIRE-BUSS 22GA TINNED	A/R
	500005	NYLON TIE CORD	A/R
	500006	CABLE STORM B24 19/38N S2V	A/R
	500043	WIRE-24GA TEFLON COATED	A/R
	501378	TEFLON TUBING [illegible]	A/R
	501448	CABLE RG 174/U 1 COND SHIELD	A/R
	524000	WIRE 24GA STR 0 COLOR	A/R
	524208	WIRE 24GA STR. 2-0-8 COLOR	A/R
	524215	WIRE 24GA STR 2-1-5 COLOR	A/R
	524728	WIRE 24GA STR 7-2-8 COLOR	A/R
	524888	WIRE 24GA STR GRAY COLOR	A/R
	524898	WIRE 24GA STR 8-9-8 COLOR	A/R
	524910	WIRE 24GA STR 9-1-0 COLOR	A/R
	524912	WIRE 24GA STR 9-1-2 COLOR	A/R
	524913	WIRE 24GA STR 9-1-3 COLOR	A/R
	524914	WIRE 24GA STR 9-1-4 COLOR	A/R
	524915	WIRE 24GA STR 9-1-5 COLOR	A/R
	524918	WIRE 24GA STR 9-1-8 COLOR	A/R

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	524920	WIRE 24GA STR 9-2-0 COLOR	A/R
	524921	WIRE 24GA STR 9-2-1 COLOR	A/R
	524922	WIRE 24GA STR 9-2-2 COLOR	A/R
	524923	WIRE 24GA STR 9-2-3 COLOR	A/R
	524924	WIRE 24GA STR 9-2-4 COLOR	A/R
	524925	WIRE 24GA STR 9-2-5 COLOR	A/R
	524928	WIRE 24GA STR 9-2-8 COLOR	A/R
	524927	WIRE 24GA STR 9-2-7 COLOR	A/R
	524928	WIRE 24GA STR 9-2-8 COLOR	A/R
	524929	WIRE 24GA STR 9-2-9 COLOR	A/R
	524930	WIRE 24GA STR 9-3-0 COLOR	A/R
	524931	WIRE 24GA STR 9-3-1 COLOR	A/R
	524932	WIRE 24GA STR 9-3-2 COLOR	A/R
	524934	WIRE 24GA STR 9-3-4 COLOR	A/R
	524935	WIRE 24GA STR 9-3-5 COLOR	A/R
	524936	WIRE 24GA STR 9-3-6 COLOR	A/R
	524939	WIRE 24GA STR 9-3-9 COLOR	A/R
	524999	WIRE 24GA STR 9-9-9 COLOR	A/R
	600018	HEATSINK IERC TABF-032-025B	2
	600032	LUG SOLDER SMITH 1418-4	1
	600068	HEAT DISS IERC LP5838	2
	600245	JUMPER-INSULATED	5
	600276	SWITCH-ROTARY	1
	600295	PLUG-CONN 8 PIN AMPH 28-4102-8P	1
	600297	CONN PC JACK	18
	600344	CONN 9 PIN AMPH 28-4101-8P	1
	610019	RIVET 1/8 SEMI-TUB I 5/32 LG	8
	610040	GROMMET-RUBBER 1/4 I D.	2
	610101	NUT-PRESS 6-32 PEM S-832-1	8
	610111	NUT PRESS 4-40 PEM S-440-1	6
	610127	#4 SHOULDER WASHER NYLON	2
	610198	#4 NYLON WASHER	4

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	610252	STDOFF-SW 4 40 X 1/8 LG 1/4D OB MTG	2
	610275	CLAMP-CABLE PL BUCMTG 3-4-1	5
	615015	SCREW PPH 2-56 X 5/16	4
	615041	SCREW PPH 4-40 X 3/16	2
	615042	SCREW PPH 4-40 X 1/4 LG.	4
	615044	SCREW PPH 4-40 X 3/8 LG	4
	615047	SCREW PPH 4-40 X 5/8 LG	2
	615058	SCREW PPH 8-32 X 5/16 LG	6
	615540	SCREW FLAT HD 4-40 X 3/16 LG	2
	617004	NUT-HEX 4-40	4
	617014	NUT-HEX 2-56 RADIO	4
	617018	NUT-HEX 4-40 RADIO	2
	617075	INT TH LOCK - WASHER #2	4
	617077	INT TH LOCK - WASHER #4	12
	617079	INT TH LOCK - WASHER #8	6
	617102	WASHER-FLAT #4	4

REF DES OR ITEM	P/N	DESCRIPTION	QTY
	920006	TRANS PAD LRG	6
	920010	SOLDER-BAR 60/37	A/R
	920026	SOLDER-WIRE	A/R
	920082	TRANS PAD ROSS 10037	2
	920056	PLUG PLASTEX 207-090241-00-0101	2
	920271	CUP ENCAPSULATING NYGLASS #4 BLK	2

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO
		LIST OF MATERIAL OR PARTS LIST			

403055	2820 V3	1	1
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS .XX ±.020 .XXX ±.010 | ANGLES 0° 30' | FORMED ANGLES ±.0

CONTRACT NO

DRAWN R. Prahal 1/68

CHECK

DESIGN

PROJ ENGR

MATERIAL

FINISH

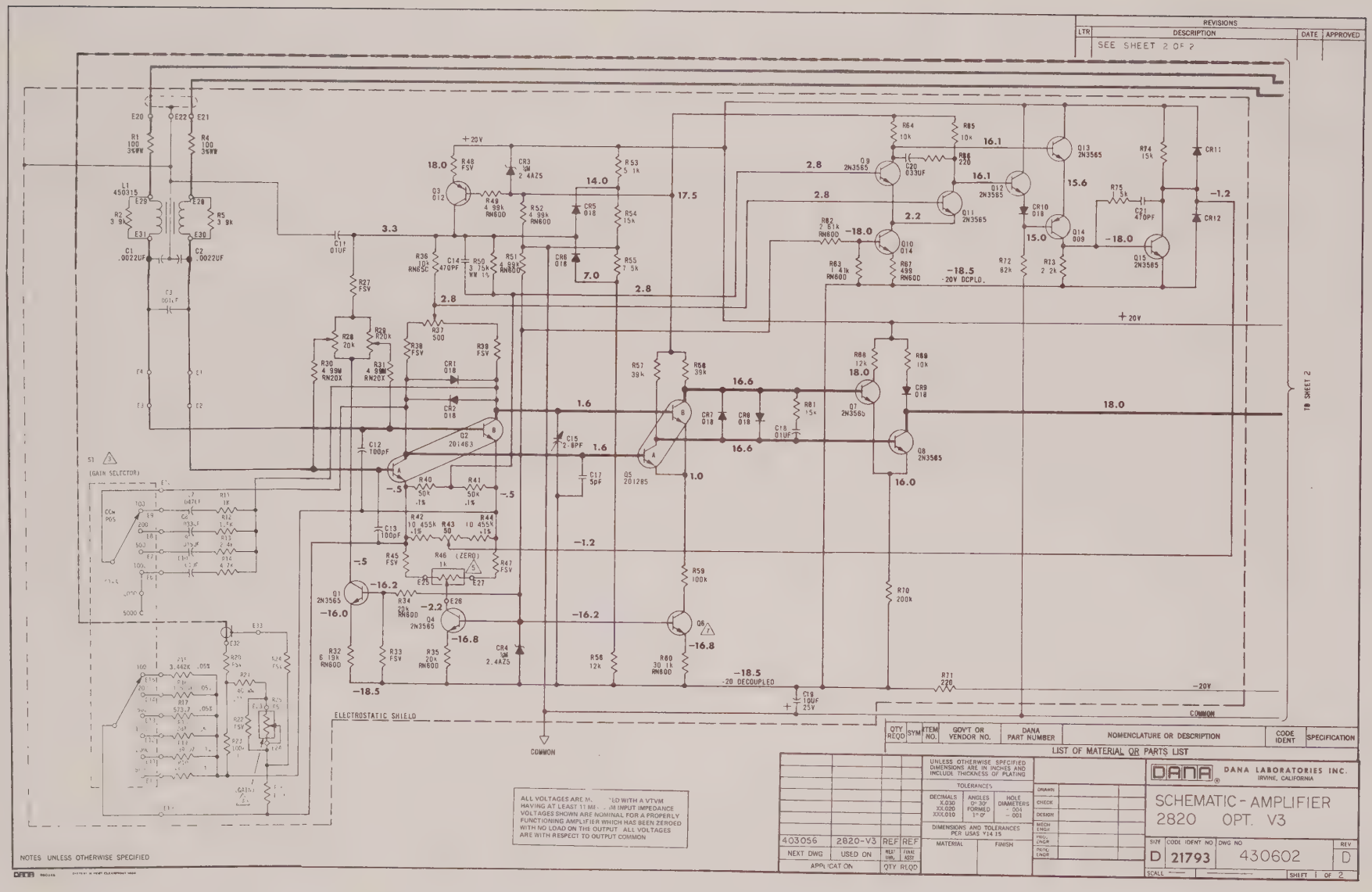
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

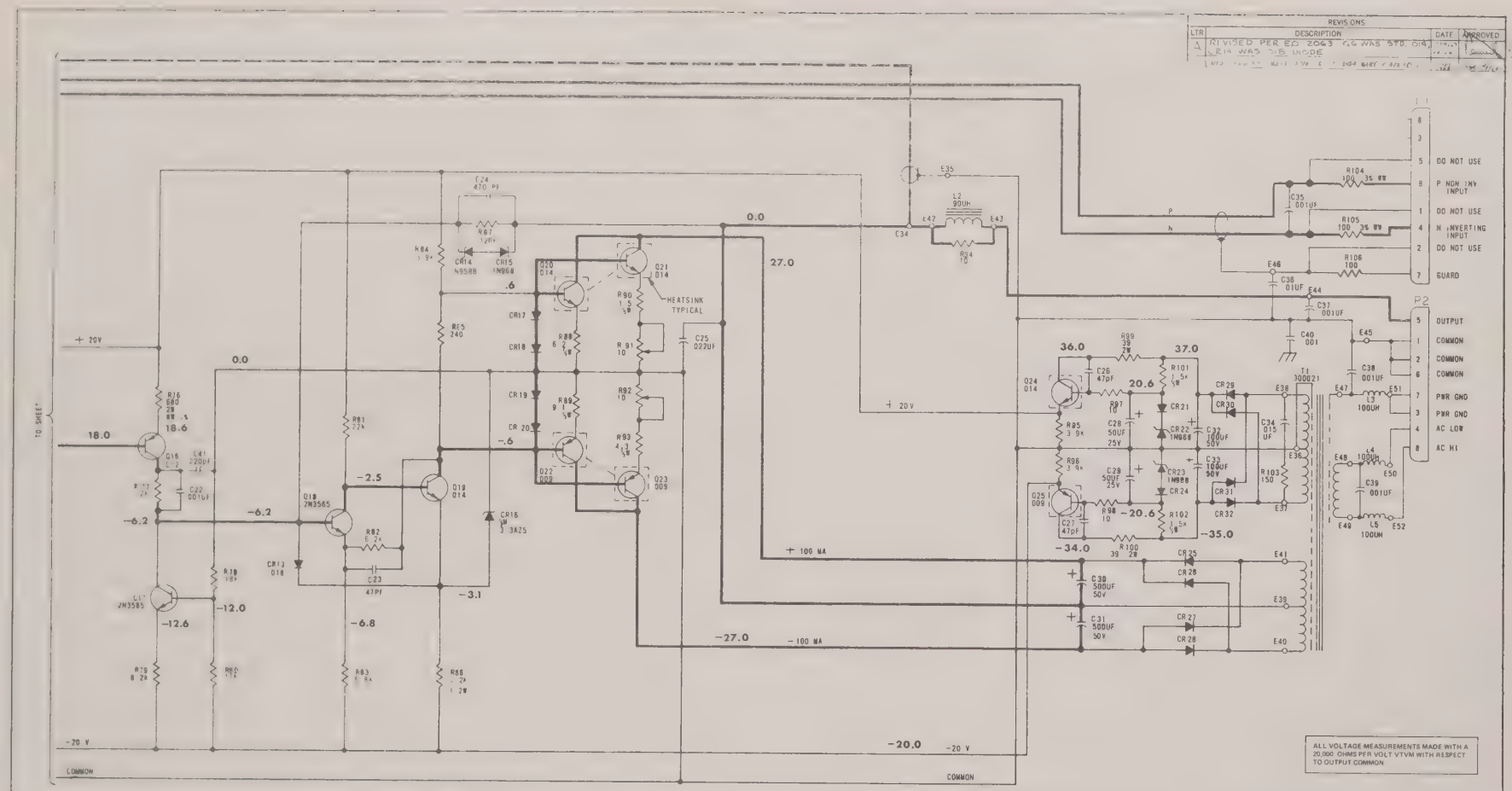
PCB ASSY — MODEL 2820 V3

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	403056	D

SCALE NONE | WT | SHEET 5 OF 5

NOTE UNLESS OTHERWISE SPECIFIED


REVISIONS
LTR | DESCRIPTION | DATE | APPROVED
SEE SHEET 2 OF 2
+20V
-20V
COMMON
ELECTROSTATIC SHIELD
(GAIN SELECTOR)
TO SHEET 2
Q1 2N3565
Q2 2N1463
Q3 012
Q4 2N3565
Q5 2N1285
Q6
Q7 2N3565
Q8 2N3565
Q9 2N3565
Q10 014
Q11 2N3565
Q12 2N3565
Q13 2N3565
Q14 009
Q15 2N3565
-18.5 -20V DCPLD.
-18.5 -20 DECOUPLED
ALL VOLTAGES ARE M... ED WITH A VTVM HAVING AT LEAST 11 ME... M INPUT IMPEDANCE VOLTAGES SHOWN ARE NOMINAL FOR A PROPERLY FUNCTIONING AMPLIFIER WHICH HAS BEEN ZEROED WITH NO LOAD ON THE OUTPUT. ALL VOLTAGES ARE WITH RESPECT TO OUTPUT COMMON
NOTES UNLESS OTHERWISE SPECIFIED
QTY REQD | SYM | ITEM NO. | GOVT OR VENDOR NO. | DANA PART NUMBER | NOMENCLATURE OR DESCRIPTION | CODE IDENT | SPECIFICATION
LIST OF MATERIAL OR PARTS LIST
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING
TOLERANCES
DECIMALS X.030 XX.020 XXX.010
ANGLES 0° 30' FORMED 1° 0°
HOLE DIAMETERS +.004 -.001
DIMENSIONS AND TOLERANCES PER USAS Y14.15
MATERIAL
FINISH
DRAWN
CHECK
DESIGN
MECH ENGR
ELEC ENGR
PROJ ENGR
403056 | 2820-V3 | REF | REF
NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY
APPLICAT ON | QTY REQD
DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA
SCHEMATIC - AMPLIFIER 2820 OPT. V3
SIZE D | CODE IDENT NO 21793 | DWG NO 430602 | REV D
SCALE | SHEET 1 OF 2



QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

4. HIGHEST REFERENCE DESIGNATORS USED C41 CR32 L5 Q25 R106
3. REFERENCE C16 NOT USED
2. ALL RESISTORS ARE IN OHMS 1 4W ± 5% CARBON
1. ALL DIODES ARE 504 S

NOTES UNLESS OTHERWISE SPECIFIED

△1 TRANSISTOR Q8 IS A SELECTED Q14 P/N 200078

6 E NUMBERS DENOTE EYELETS AND CORRESPOND TO POINTS ON PC BOARD SEE ASSY DWGS = 402305 (BASIC 3RD ASSY) AND 402304 (3RD ASSY W OPTION ADDED.

5 R25(GAIN) R46(ZERO) & S1(GAIN SELECTOR) ARE FRONT PANEL ADJUSTMENT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS	ANGLES	HOLE DIAMETERS
X .030	0° 30'	.005
XX .020	FORMED	.001
XXX .010	1° 0'	

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL FINISH

DRAWN CHECK DESIGN MECH ENGR ELEC ENGR PROJ ENGR

403056 2820-V3 REF REF

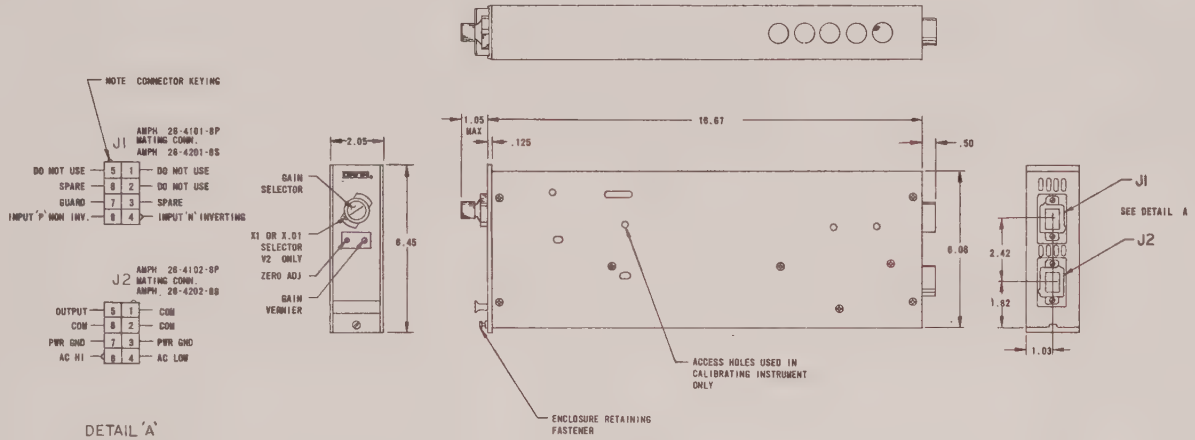
NEXT DWG USED ON APPLICATION QTY REQ

DANA DANA LABORATORIES INC IRVINE, CALIFORNIA

SCHEMATIC-AMPLIFIER 2820 OPT. V3

SIZE D CODE IDENT NO 21793 DWG NO 430602 REV D

SCALE SHEET 2 OF 2



DETAIL 'A'

WIRING TYPICAL OF DANA CORD SET NO 402400 AND DANA MODEL 2008-1 & 2008-2 ENCLOSURE

1. OUTLINE TYPICAL FOR 2820 OPTIONS V1, V2, & V3.

NOTE: UNLESS OTHERWISE SPECIFIED

APPLICATION		QTY REQD	
402389	2820 V3	REF	REF
402301	2820 V2	REF	REF
402300	2820 V1	REF	REF
NEXT ASSY	USED ON	NA	FA

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS X .03 .XX .010 .XXX .005 | ANGLES 0° 30' | FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN	G WILSON	6/21/67
CHECK		
COG ENGR		
PROJ ENGR		

DRAWN BY

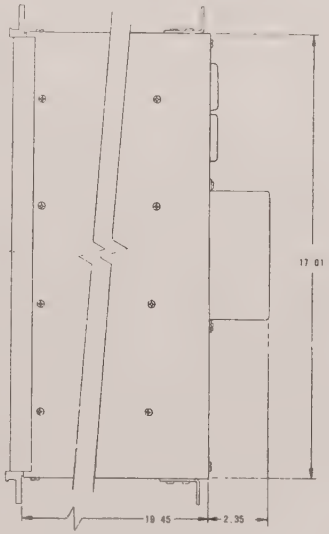
Rev. 11-14-67

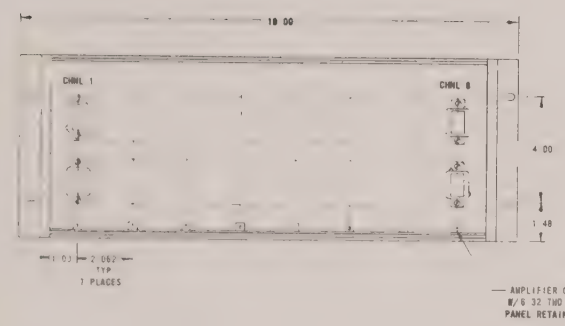
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

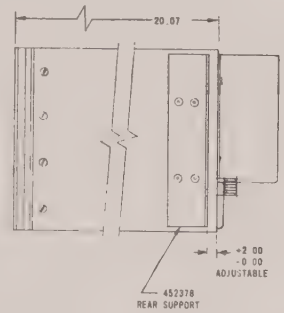
OUTLINE DIMENSIONAL AMPLIFIER MODEL 2820

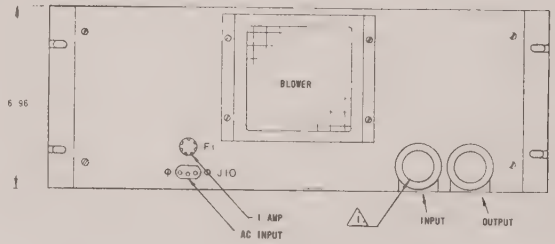
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	452400	A

SCALE 1/2 | WT | SHEET 1 OF 1









⚠ ENCLOSURE W/BINS PER DANA DRAWING # 430500.

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X .030, XX .020, XXX .010
ANGLES 0° 30'
FORMED ANGLES 1.0
MATERIAL
FINISH

CONTRACT NO.

DRAWN G WILSON 6/2/87
CHECK W.E. Sullivan 23 June 87
ENGR A.E.S. 6/24/87
PROJ ENGR [illegible] 6/24/87

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

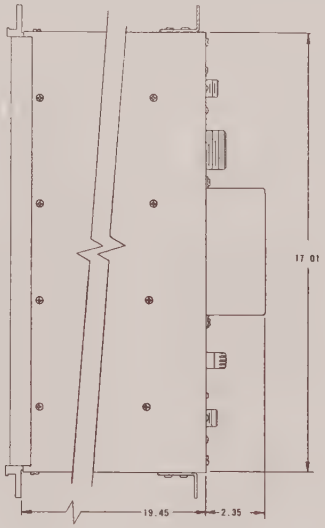
OUTLINE DIMENSIONAL
ENCLOSURE
MODEL 2808-1

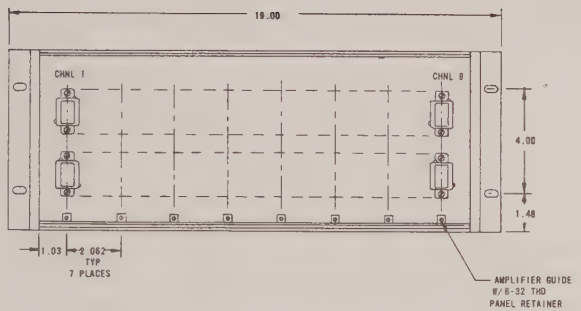
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	452402	

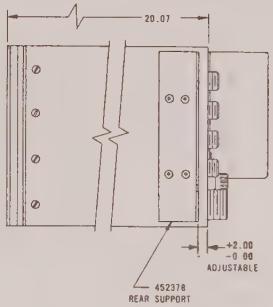
SCALE 1/2 WT SHEET 1 OF 1

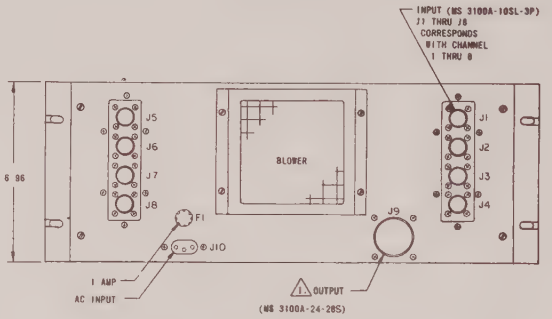
NEXT ASSY	USED ON	REF	REF
402368	2808-1	NA	NA
APPLICATION		QTY REQD	

DRAWN/LRE 12-04-87









QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

402371	2808 2	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .030, XX .020, XXX .010
ANGLES 0° 30'
FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN	G WILSON	6/22/67
CHECK		
COG ENGR		
PROJ ENGR		6/29/67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

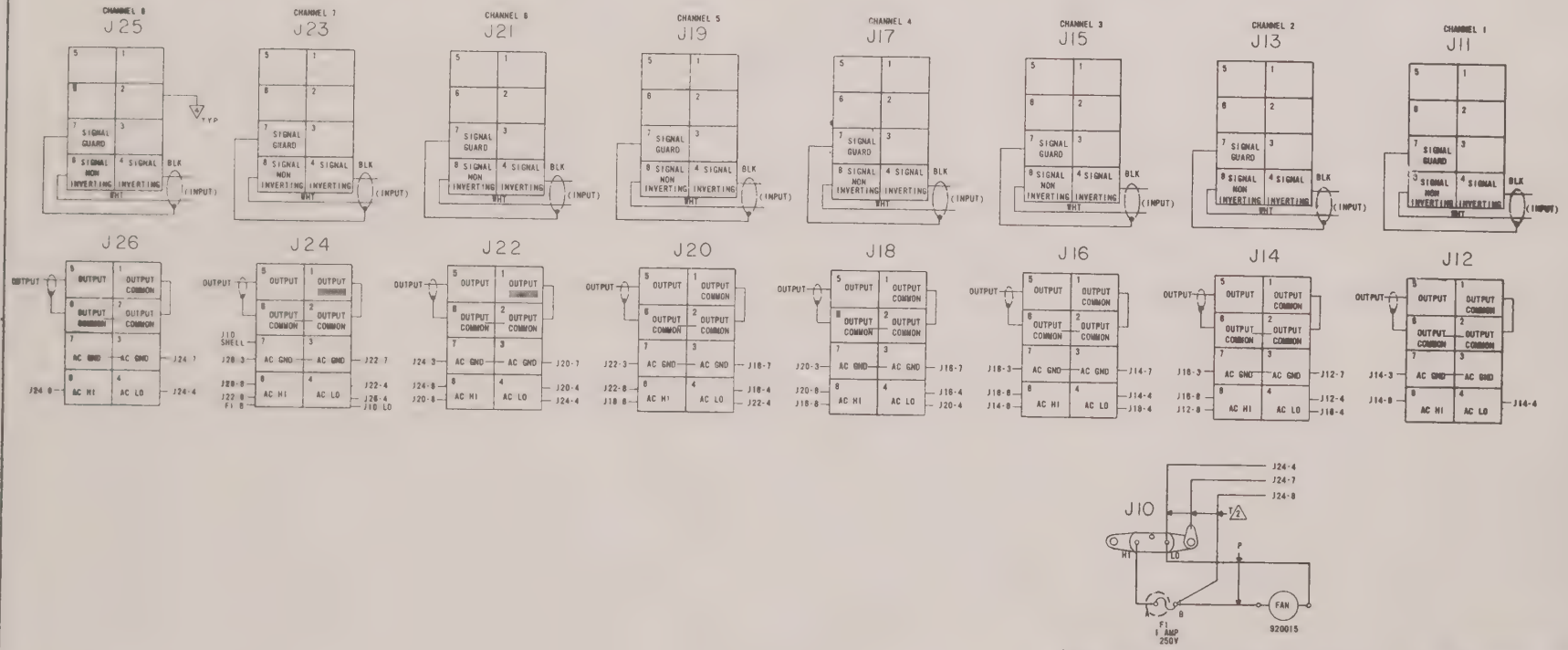
OUTLINE DIMENSIONAL ENCLOSURE MODEL 2808-2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	452403	

SCALE 1/2 | WT | SHEET 1 OF 1

⚠1 ENCLOSURE WIRING PER DANA DRAWING # 430581.

NOTE: UNLESS OTHERWISE SPECIFIED



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ANGLES FORMED ANGLES 0° 30' 1.0

MATERIAL

FINISH

402368	2808-1	REF	R/F
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

CONTRACT NO.

DRAWN A.B.SCOTT 7/9/87

CHECK

DOC ENGR

PROJ ENGR

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

WIRING DIAGRAM — 2808
ENCLOSURE, OPT. 1

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430590	C

SCALE NONE WT SHEET 1 OF 2

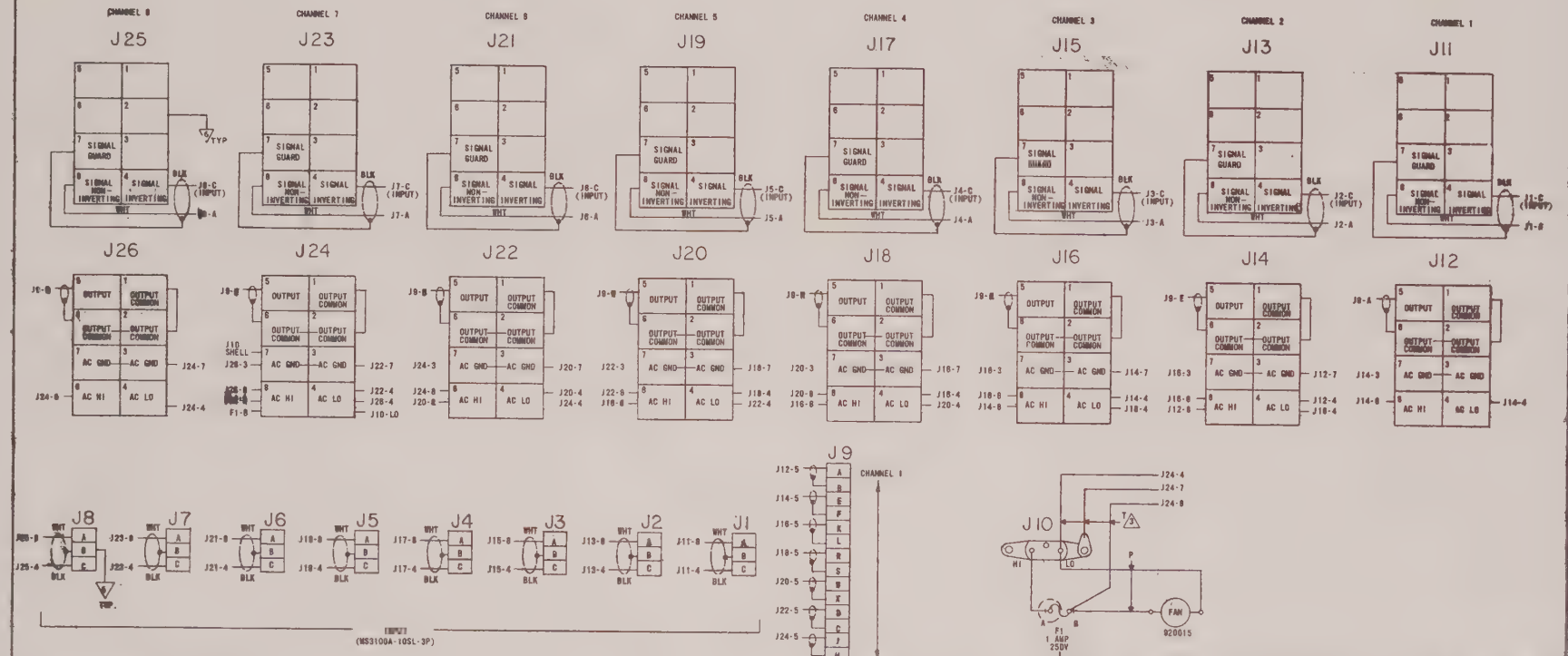
▽ PIN 2 TIED TO GROUND LUG MOUNTED ON CONNECTORS J11, 13 15 17 19, 21, 23 AND J26 USING 24AWG WIRE.

B. INTERCONNECTIONS ON CONNECTORS USING 500004 WIRE AND 501378 SLEEVING AS REQUIRED.

⚠ ALL AC POWER WIRING TO BE TWISTED.

1. WIRE PER DANA WORKMANSHIP AND PROCEDURE STANDARDS

NOTE: UNLESS OTHERWISE SPECIFIED



PIN B TIED TO GROUND LUG MOUNTED ON CONNECTORS J11, J25, J23, J21, J19, J17, J15, J13, J11 USING [illegible] WIRE.

PIN B ON J1 THRU J8 TO BE TIED TO GROUND LUG MOUNTED ON CONN SHELL USING 500062 WIRE.

4. INTERCONNECTIONS ON CONNECTORS USING 500004 WIRE AND 501370 SLEEVING AS REQUIRED.

1. ALL AC POWER WIRING TO BE TWISTED.

2. ROUTE AND TIE HARNESSES AND OTHER WIRING PERMITTING REAR PANEL TO OPEN APPROXIMATELY 120°. USE CLAMPS AS REQUIRED TO KEEP CABLES CLEAR OF OPENING ON CONNECTOR MOUNTING BRACKET

WIRE PER DANA WORKMANSHIP AND PROCEDURE STANDARDS.

UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

402371	2808-2	QPL	COMP
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS | ANGLES | FORMED ANGLES
.XX ±.020 | 0° 30' | ±1.0
.XXX ±.010

MATERIAL

FINISH

CONTRACT NO.

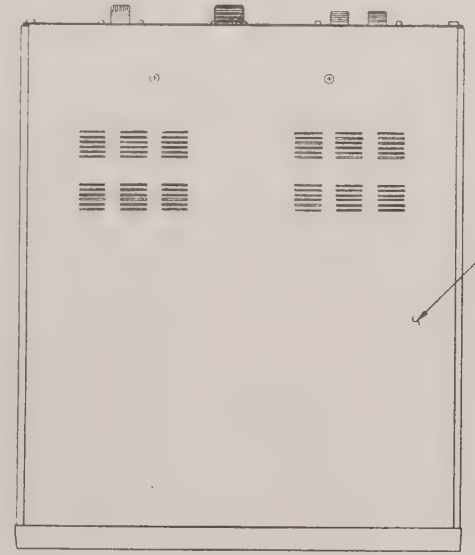
DRAWN: ABBOTT 7/5/67
CHECK:
COG. ENGR.
PROJ. ENGR.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

WIRING DIAGRAM — 2808 ENCLOSURE, OPT. 2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430591	

SCALE NONE | WT. | SHEET



452697 COVER
ENCLOSURE TOP
615557 SCREW
6-32 x 5/16 FLAT HD PH
2 REQD

POWER CORD DETAIL
SCALE: NONE

402851 CABLE
ASSY PWR A C

BOTTOM ENCLOSURE
COVER (SEE SHEET 4)
613557 SCREW
6-32 x 5/16 FLAT HD PH
2 REQD

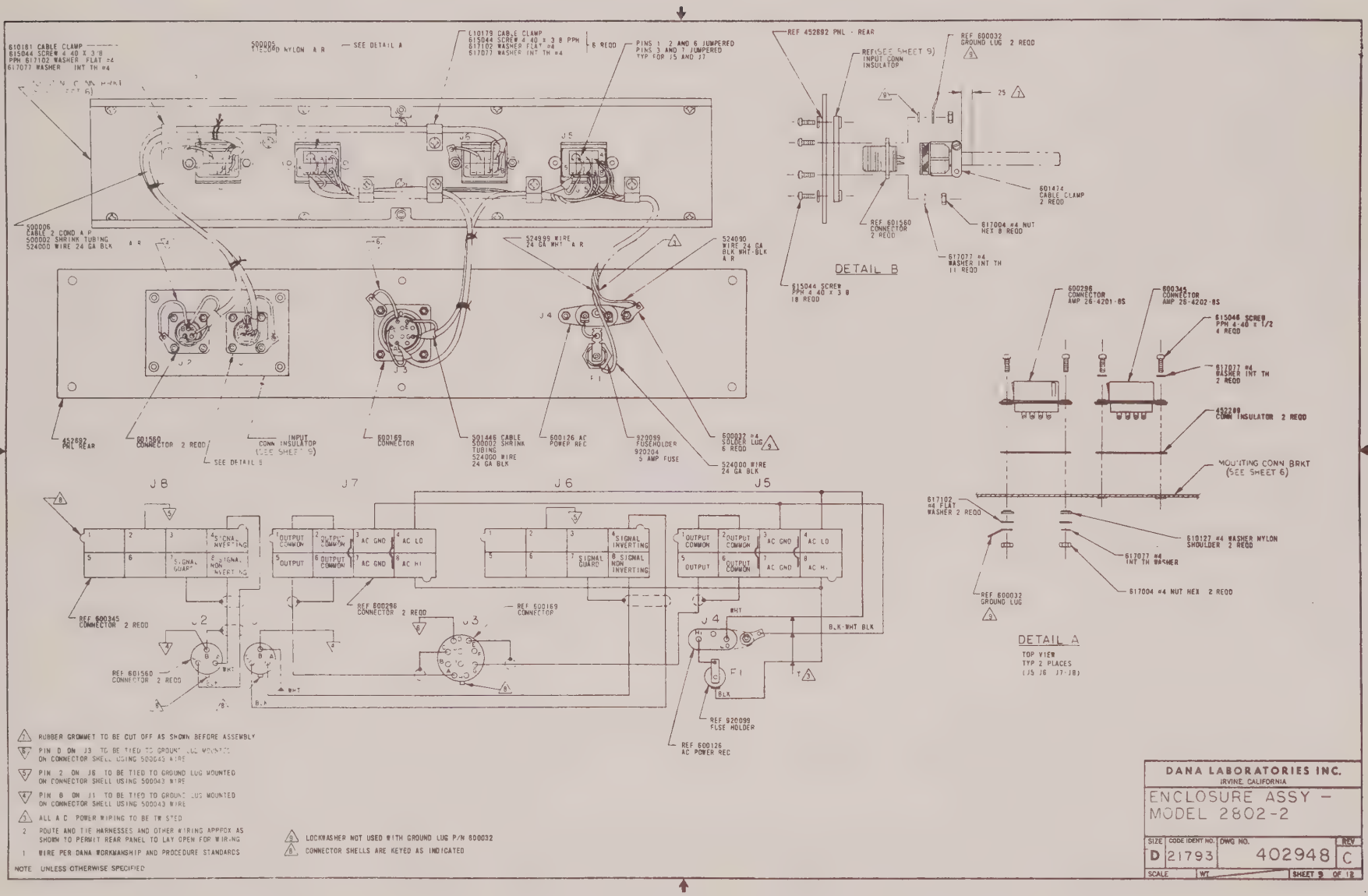
FRONT ENCLOSURE
PANEL (SEE SHEET 5)

2. REF OUTLINE DIMENSIONAL DRAWING NO 452702

1 ASSEMBLY PROCEDURE AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS

NOTE UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC. IRVINE, CALIFORNIA			
ENCLOSURE ASSY - MODEL 2802-2			
SIZE	CODE IDENT NO.	DWG NO.	REV.
D	21793	402948	C
SCALE 1/2	WT	SHEET 1 OF 12	


610181 CABLE CLAMP
615044 SCREW 4-40 X 3/8 PPH
617102 WASHER FLAT #4
617077 WASHER INT TH #4
500005 TIE CORD NYLON A R
SEE DETAIL A
610179 CABLE CLAMP
615044 SCREW 4-40 X 3/8 PPH
617102 WASHER FLAT #4
617077 WASHER INT TH #4
6 REQD
PINS 1 2 AND 6 JUMPERED
PINS 3 AND 7 JUMPERED
TYP FOR J5 AND J7
500006
CABLE 2 COND A R
500002 SHRINK TUBING
524000 WIRE 24 GA BLK
A R
524999 WIRE 24 GA WHT A R
524090 WIRE 24 GA BLK WHT-BLK A R
452692 PNL REAR
601560 CONNECTOR 2 REQD
INPUT CONN INSULATOR (SEE SHEET 9)
600188 CONNECTOR
501445 CABLE 500002 SHRINK TUBING 524000 WIRE 24 GA BLK
600126 AC POWER REC
920098 FUSEHOLDER
920204 5 AMP FUSE
600032 #4 SOLDER LUG 6 REQD
524000 WIRE 24 GA BLK
SEE DETAIL B
REF 452692 PNL - REAR
REF (SEE SHEET 9) INPUT CONN INSULATOR
REF 600032 GROUND LUG 2 REQD
601474 CABLE CLAMP 2 REQD
REF 601560 CONNECTOR 2 REQD
617004 #4 NUT HEX 8 REQD
617077 #4 WASHER INT TH 11 REQD
615044 SCREW PPH 4-40 X 3/8 18 REQD
DETAIL B
600296 CONNECTOR AMP 26-4201-8S
600342 CONNECTOR AMP 26-4202-8S
615048 SCREW PPH 4-40 X 1/2 4 REQD
617077 #4 WASHER INT TH 2 REQD
452289 CONN INSULATOR 2 REQD
MOUNTING CONN BRKT (SEE SHEET 6)
617102 #4 FLAT WASHER 2 REQD
610127 #4 WASHER NYLON SHOULDER 2 REQD
617077 #6 INT TH WASHER
617004 #4 NUT HEX 2 REQD
REF 600032 GROUND LUG
DETAIL A
TOP VIEW
TYP 2 PLACES
(J5 J6 J7 J8)
J8
J7
J6
J5
SIGNAL INVERTING
SIGNAL GUARD
SIGNAL NON INVERTING
OUTPUT COMMON
OUTPUT
AC GND
AC LO
AC HI
REF 600345 CONNECTOR 2 REQD
REF 601560 CONNECTOR 2 REQD
REF 600296 CONNECTOR 2 REQD
REF 600169 CONNECTOR
J2
J3
J4
F1
WHT
BLK
BLK-WHT BLK
REF 920098 FUSE HOLDER
REF 600126 AC POWER REC

1. RUBBER GROMMET TO BE CUT OFF AS SHOWN BEFORE ASSEMBLY
2. PIN D ON J3 TO BE TIED TO GROUND LUG MOUNTED ON CONNECTOR SHELL USING 500043 WIRE
3. PIN 2 ON J6 TO BE TIED TO GROUND LUG MOUNTED ON CONNECTOR SHELL USING 500043 WIRE
4. PIN B ON J1 TO BE TIED TO GROUND LUG MOUNTED ON CONNECTOR SHELL USING 500043 WIRE
5. ALL A C POWER WIRING TO BE TWISTED
2. ROUTE AND TIE HARNESSES AND OTHER WIRING APPROX AS SHOWN TO PERMIT REAR PANEL TO LAY OPEN FOR WIRING
1. WIRE PER DANA WORKMANSHIP AND PROCEDURE STANDARDS

NOTE UNLESS OTHERWISE SPECIFIED

3. LOCKWASHER NOT USED WITH GROUND LUG P/N 600032
6. CONNECTOR SHELLS ARE KEYED AS INDICATED

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ENCLOSURE ASSY - MODEL 2802-2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402948	C

SCALE | WT | SHEET 9 OF 12

PARTS LIST

ASSEMBLY 402939 - Model 2820

REF. DESIG.	PART NO.	DESCRIPTION					
C01	121092	CAP MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22
C02	121092	CAP MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22
C03	101174	CAP CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C04		NOT USED					
C05		NOT USED					
C06		NOT USED					
C07	121093	CAP MYLAR	.047 MFD	100 V	10%	CDE	WMF1S47
C08	121091	CAP MYLAR	.033 MFD	100 V	10%	CDE	WMF1533
C09	121090	CAP MYLAR	.015 MFD	100 V	10%	CDE	WMF1S15
C10	121088	CAP MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1
C11	121088	CAP MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1
C12	101145	CAP CERAM	100 PFD	500 V	10%	AEROVOX	SCD1X5F
C13	101145	CAP CERAM	100 PFD	500 V	10%	AEROVOX	SCD1X5F
C14	101641	CAP CERAM	470 PFD	500 V	10%	AEROVOX	SCD1X5F
C15	130004	CAP CERAM	2-8 PFD	500 V	10%	ERIE	538-00289R
C16		NOT USED					
C17	100009	CAP CERAM	5 PFD	500 V	10%	AEROVOX	TCD-N750
C18	121088	CAP MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1
C19	111262	CAP ELECT	10 MFD	25 V	20%	SPRAGUE	TE1204
C20	121091	CAP MYLAR	.033 MFD	100 V	10%	CDE	WMF1533
C21	101641	CAP CERAM	470 PFD	500 V	10%	AEROVOX	SCD1X5F
C22	101174	CAP CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C23	101182	CAP CERAM	47 PFD	500 V	10%	AEROVOX	TCD-N750
C24	101641	CAP CERAM	470 PFD	500 V	10%	AEROVOX	SCD1X5F
C25	121468	CAP MYLAR	.022 MFD	100 V	10%	CDE	WMF1S22
C26	101182	CAP CERAM	47 PFD	500 V	10%	AEROVOX	TCD-N750
C27	101182	CAP CERAM	47 PFD	500 V	10%	AEROVOX	TCD-N750
C28	110060	CAP ELECT	50 MFD	25 V		SPRAGUE	TE1209
C29	110060	CAP ELECT	50 MFD	25 V		SPRAGUE	TE1209
C30	110062	CAP ELECT	500 MFD	50 V		SPRAGUE	39D507G050L4
C31	110062	CAP ELECT	500 MFD	50 V		SPRAGUE	39D507G050L4
C32	110061	CAP ELECT	100 MFD	50 V		SPRAGUE	39D107G050EJ4
C33	110061	CAP ELECT	100 MFD	50 V		SPRAGUE	39D107G050EJ4
C34	121090	CAP MYLAR	.015 MFD	100 V	10%	CDE	WMF1S15
C35	101174	CAP CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C36	100017	CAP CERAM	.01 MFD	200 V	10%	SPRAGUE	TH-S10
C37	101174	CAP CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C38	101174	CAP CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C39	101174	CAP CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F

PARTS LIST

ASSEMBLY 402939 - Model 2820

REF. DESIG.	PART NO.	DESCRIPTION	
C40	101174	CAP CERAM .001 MFD 500 V 10%	AEROVOX SCD3X5F
C41	101175	CAP CERAM 220 PFD 500 V 10%	AEROVOX SCD1X5F
CR01	211083	DIODE SILICO 018	DANA 211083
CR02	211083	DIODE SILICO 018	DANA 211083
CR03	221177	DIODE SILICO ZENER 1/4 W	MOTOROLA M.2.4A25
CR04	221177	DIODE SILICO ZENER 1/4 W	MOTOROLA M.2.4A25
CR05	211083	DIODE SILICO 018	DANA 211083
CR06	211083	DIODE SILICO 018	DANA 211083
CR07	211083	DIODE SILICO 018	DANA 211083
CR08	211083	DIODE SILICO 018	DANA 211083
CR09	211083	DIODE SILICO 018	DANA 211083
CR10	211083	DIODE SILICO 018	DANA 211083
CR11	210004	DIODE SILICO SD4	DIODES IN SD4
CR12	210004	DIODE SILICO SD4	DIODES IN SD4
CR13	211083	DIODE SILICO 018	DANA 211083
CR14	220012	DIODE SILICO ZENER 1N958B	MOTOROLA 1N958B
CR15	220011	DIODE SILICO ZENER 1N968A	MOTOROLA 1N968A
CR16	220031	DIODE SILICO ZENER 1/4M3.3AZ5	MOTOROLA 1/4M3.3AZ5
CR17	210004	DIODE SILICO SD4	DIODES IN SD4
CR18	210004	DIODE SILICO SD4	DIODES IN SD4
CR19	210004	DIODE SILICO SD4	DIODES IN SD4
CR20	210004	DIODE SILICO SD4	DIODES IN SD4
CR21	210004	DIODE SILICO SD4	DIODES IN SD4
CR22	220011	DIODE SILICO ZENER 1N968A	MOTOROLA 1N968A
CR23	220011	DIODE SILICO ZENER 1N968A	MOTOROLA 1N968A
CR24	210004	DIODE SILICO SD4	DIODES IN SD4
CR25	210004	DIODE SILICO SD4	DIODES IN SD4
CR26	210004	DIODE SILICO SD4	DIODES IN SD4
CR27	210004	DIODE SILICO SD4	DIODES IN SD4
CR28	210004	DIODE SILICO SD4	DIODES IN SD4
CR29	210004	DIODE SILICO SD4	DIODES IN SD4
CR30	210004	DIODE SILICO SD4	DIODES IN SD4
CR31	210004	DIODE SILICO SD4	DIODES IN SD4
CR32	210004	DIODE SILICO SD4	DIODES IN SD4
L01	400315	CHOKE ASSY	AZTEC 10438
L02	400324	OUTPUT CHOKE ASSEMBLY	DANA 400324
L03	310033	CHOKE 100 MH	MILLER 9210-76

PARTS LIST

ASSEMBLY 402939 - Model 2820

REF. DESIG.	PART NO.	DESCRIPTION						
L04	310033	CHOKE		100 MH			MILLER	9210-76
L05	310033	CHOKE		100 MH			MILLER	9210-76
Q01	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q02	402716	ASSY		FSV 2820	V1		DANA	402716
Q03	200022	TRANS SILICO PNP		012			DANA	200022
Q04	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q05	201285	TRANS DUAL NPN		016S			DANA	201285
Q06	200078	TRANS SILICO NPN		FSV			DANA	200078
Q07	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q08	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q09	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q10	200035	TRANS SILICO NPN		014			DANA	200035
Q11	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q12	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q13	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q14	200011	TRANS SILICO PNP		009			DANA	200011
Q15	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q16	200022	TRANS SILICO PNP		012			DANA	200022
Q17	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q18	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q19	200035	TRANS SILICO NPN		014			DANA	200035
Q20	200035	TRANS SILICO NPN		014			DANA	200035
Q21	200035	TRANS SILICO NPN		014			DANA	200035
Q22	200011	TRANS SILICO PNP		009			DANA	200011
Q23	200011	TRANS SILICO PNP		009			DANA	200011
Q24	200035	TRANS SILICO NPN		014			DANA	200035
Q25	200011	TRANS SILICO PNP		009			DANA	200011
R01	020106	RES WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R02	000392	RES CARBON	0003.9 K	5%	1/4 W		OHMITE	RC07GF392J
R03		NOT USED						
R04	020106	RES WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R05	000392	RES CARBON	0003.9 K	5%	1/4 W		OHMITE	RC07GF392J
R06		NOT USED						
R07		NOT USED						
R08		NOT USED						
R09		NOT USED						
R10		NOT USED						
R100	030003	RES WW	39 OHM	2W	1/8 W		JORDAN	J-11
R101	001682	RES CARBON	1.5 K	5%	1/2 W		OHMITE	RC20GF152J

PARTS LIST

ASSEMBLY 402939 - Model 2820 A

REF. DESIG.	PART NO.	DESCRIPTION								
R102	001682	RES	CARBON	1.5	K	5%	1/2	W	OHMITE	RC20GF152J
R103	000151	RES	CARBON	150	OHM	5%	1/4	W	OHMITE	RC07GF151J
R104	020106	RES	WW	100	OHM	.3%	1/8	W	CF ELEC	CF-4012
R105	020106	RES	WW	100	OHM	.3%	1/8	W	CF ELEC	CF-4012
R106	000101	RES	CARBON	100	OHM	5%	1/4	W	OHMITE	RC07GF101J
R11	000621	RES	CARBON	620	OHM	5%	1/4	W	OHMITE	RC07GF621J
R12	000152	RES	CARBON	1.5	K	5%	1/4	W	OHMITE	RC07GF152J
R13	000242	RES	CARBON	2.4	K	5%	1/4	W	OHMITE	RC07GF242J
R14	000472	RES	CARBON	4.7	K	5%	1/4	W	OHMITE	RC07GF472J
R15	020424	RES	WW	9.179	K	.05%			JORDAN	J11
R16	020423	RES	WW	3.442	K	.05%			JORDAN	J11
R17	020422	RES	WW	1.530	K	.05%			JORDAN	J11
R18	020421	RES	WW	573.7	OHM	.05%			JORDAN	J11
R19	020420	RES	WW	281	OHM	.05%			CF	M18
R20	402717	ASSY			FSV	2820	V2		DANA	402717
R21	020086	RES	WW	840	OHM	.1%	1/8	W	KELVIN	EP-20
R22	402716	ASSY			FSV	2820	V1		DANA	402716
R23	020079	RES	WW	100	K	.1%	1/8	W	JORDAN	J-11
R24	402716	ASSY			FSV	2820	V1		DANA	402716
R25	402716	ASSY			FSV	2820	V1		DANA	402716
R26	020079	RES	WW	100	K	.1%	1/8	W	JORDAN	J-11
R27	402716	ASSY			FSV	2820	V1		DANA	402716
R28	040092	RES	VARI	20	K				SPECTRO	50-3-1-203
R29	040092	RES	VARI	20	K				SPECTRO	50-3-1-203
R30	011178	RES	METAL	4.99	K	1%	1/4	W	ELECTRA	RN20X4994F
R31	011178	RES	METAL	4.99	K	1%	1/4	W	ELECTRA	RN20X4994F
R32	010130	RES	METAL	6.19	K	1%	1/4	W	ELECTRA	RN60D6191F
R33	402716	ASSY			FSV	2820	V1		DANA	402716
R34	010059	RES	METAL	20	K	1%	1/4	W	ELECTRA	RN60D2002F
R35	010059	RES	METAL	20	K	1%	1/4	W	ELECTRA	RN60D2002F
R36	010110	RES	METAL	10	K	1%	1/2	W	ELECTRA	RN65C1002F
R37	040093	RES	VARI	500	OHM				SPECTRO	50-3-1-501
R38	402716	ASSY			FSV	2820	V1		DANA	402716
R39	402716	ASSY			FSV	2820	V1		DANA	402716
R40	020078	RES	WW	50	K	.1%	1/8	W	JORDAN	J-11
R41	020078	RES	WW	50	K	.1%	1/8	W	JORDAN	J-11
R42	020425	RES	WW	10.455	K	.1%			CF	M20
R43	040108	RES	VARI	50	OHM				SPECTROL	50-3
R44	020425	RES	WW	10.455	K	.1%			CF	M20

PARTS LIST

ASSEMBLY 402939 - Model 2820

REF. DESIG.	PART NO.	DESCRIPTION							
R45	402716	ASSY			FSV 2820	V1		DANA	402716
R46	040020	RES	VARI	1 K	10%	1/4 W		BOURNS	271-1-102-
R47	402716	ASSY			FSV 2820	V1		DANA	402716
R48	402716	ASSY			FSV 2820	V1		DANA	402716
R49	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R50	020104	RES	WW	3.75 K	1%	1/8 W		CF ELEC	CF3133
R51	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R52	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R53	000512	RES	CARBON	5.1 K	5%	1/4 W		OHMITE	RC07GF512J
R54	000153	RES	CARBON	15 K	5%	1/4 W		OHMITE	RC07GF153J
R55	000752	RES	CARBON	7.5 K	5%	1/4 W		OHMITE	RC07GF752J
R56	000123	RES	CARBON	12 K	5%	1/4 W		OHMITE	RC07GF123J
R57	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R58	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R59	000104	RES	CARBON	100 K	5%	1/4 W		OHMITE	RC07GF104J
R60	010019	RES	METAL	30.1 K	1%	1/4 W		ELECTRA	RN60B3012F
R61	000153	RES	CARBON	15 K	5%	1/4 W		OHMITE	RC07GF153J
R62	011334	RES	METAL	2.61 K	1%	1/4 W		ELECTRA	RN60D2611F
R63	010008	RES	METAL	1.4 K	1%	1/4 W		IRC	RN60D142F
R64	000103	RES	CARBON	10 K	5%	1/4 W		OHMITE	RC07GF103J
R65	000103	RES	CARBON	10 K	5%	1/4 W		OHMITE	RC07GF103J
R66	000221	RES	CARBON	220 OHM	5%	1/4 W		OHMITE	RC07GF221J
R67	010027	RES	METAL	499 OHM	1%	1/4 W		ELECTRA	RN60D4990F
R68	000123	RES	CARBON	12 K	5%	1/4 W		OHMITE	RC07GF123J
R69	000103	RES	CARBON	10 K	5%	1/4 W		OHMITE	RC07GF103J
R70	000204	RES	CARBON	200 K	5%	1/4 W		OHMITE	RC07GF204J
R71	000221	RES	CARBON	220 OHM	5%	1/4 W		OHMITE	RC07GF221J
R72	000823	RES	CARBON	82 K	5%	1/4 W		OHMITE	RC07GF823J
R73	000222	RES	CARBON	2.2 K	5%	1/4 W		OHMITE	RC07GF222J
R74	000153	RES	CARBON	15 K	5%	1/4 W		OHMITE	RC07GF153J
R75	000152	RES	CARBON	1.5 K	5%	1/4 W		OHMITE	RC07GF152J
R76	020119	RES	WW	680 OHM	1%	1/2 W		CF ELEC	M-20
R77	000123	RES	CARBON	12 K	5%	1/4 W		OHMITE	RC07GF123J
R78	000183	RES	CARBON	18 K	5%	1/4 W		OHMITE	RC07GF183J
R79	000622	RES	CARBON	6.2 K	5%	1/4 W		OHMITE	RC07GF622J
R80	000113	RES	CARBON	11 K	5%	1/4 W		OHMITE	RC07GF113J
R81	000223	RES	CARBON	22 K	5%	1/4 W		OHMITE	RC07GF223J

PARTS LIST

ASSEMBLY 402939 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
R82	CC0622	RES	CARBON	6.2	K	5%	1/4 W	OHMITE	RC07GF622J
R83	000682	RES	CARBON	6.8	K	5%	1/4 W	OHMITE	RC07GF682J
R84	CC0392	RES	CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R85	CC0241	RES	CARBON	240	OHM	5%	1/4 W	OHMITE	RC07GF241J
R86	CC1469	RES	CARBON	1.2	K	5%	1/2 W	OHMITE	RC20GF122J
R87	CC0124	RES	CARBON	120	K	5%	1/4 W	OHMITE	RC07GF124J
R88	001740	RES	CARBON	6.2	OHM	5%	1/2 W	OHMITE	RC20GF060J
R89	001741	RES	CARBON	9.1	OHM	5%	1/2 W	OHMITE	RC20GF090J
R90	001738	RES	CARBON	1.5	OHM	5%	1/2 W	OHMITE	RC20GF010J
R91	C41476	RES	VARI	100	OHM	10%	1/4 W	CTS	BK24376
R92	041476	RES	VARI	100	OHM	10%	1/4 W	CTS	BK24376
R93	001739	RES	CARBON	4.3	OHM	5%	1/2 W	OHMITE	RC20GF040J
R94	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R95	000392	RES	CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R96	CC0392	RES	CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R97	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R98	CC0100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R99	030003	RES	WW	39	OHM	2w	1/8 W	JORDAN	J-11
T01	300021	TRANSFORMER						AZTEC	6242

PARTS LIST

ASSEMBLY 402940 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
C01	121092	CAP	MYLAR	.0022	MFD	100 V	10%	CDE	WMF1D22
C02	121092	CAP	MYLAR	.0022	MFD	100 V	10%	CDE	WMF1D22
C03	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F
C04	100006	CAP	CERAM	10	PFD	500 V	10%	AEROVOX	TCD-N750
C05	130004	CAP	CERAM	2-8	PFD	500 V	10%	ERIE	538-00289R
C06	101641	CAP	CERAM	470	PFD	500 V	10%	AEROVOX	SCD1X5F
C07	121093	CAP	MYLAR	.047	MFD	100 V	10%	CDE	WMF1S47
C08	121091	CAP	MYLAR	.033	MFD	100 V	10%	CDE	WMF1533
C09	121090	CAP	MYLAR	.015	MFD	100 V	10%	CDE	WMF1S15
C10	121088	CAP	MYLAR	.01	MFD	100 V	10%	CDE	WMF1S1
C11	121088	CAP	MYLAR	.01	MFD	100 V	10%	CDE	WMF1S1
C12	101145	CAP	CERAM	100	PFD	500 V	10%	AEROVOX	SCD1X5F
C13	101145	CAP	CERAM	100	PFD	500 V	10%	AEROVOX	SCD1X5F
C14	101641	CAP	CERAM	470	PFD	500 V	10%	AEROVOX	SCD1X5F
C15	130004	CAP	CERAM	2-8	PFD	500 V	10%	ERIE	538-00289R
C16		NOT USED							
C17	100009	CAP	CERAM	5	PFD	500 V	10%	AEROVOX	TCD-N750
C18	121088	CAP	MYLAR	.01	MFD	100 V	10%	CDE	WMF1S1
C19	111262	CAP	ELECT	10	MFD	25 V	20%	SPRAGUE	TE1204
C20	121091	CAP	MYLAR	.033	MFD	100 V	10%	CDE	WMF1533
C21	101641	CAP	CERAM	470	PFD	500 V	10%	AEROVOX	SCD1X5F
C22	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F
C23	101182	CAP	CERAM	47	PFD	500 V	10%	AEROVOX	TCD-N750
C24	101641	CAP	CERAM	470	PFD	500 V	10%	AEROVOX	SCD1X5F
C25	121468	CAP	MYLAR	.022	MFD	100 V	10%	CDE	WMF1S22
C26	101182	CAP	CERAM	47	PFD	500 V	10%	AEROVOX	TCD-N750
C27	101182	CAP	CERAM	47	PFD	500 V	10%	AEROVOX	TCD-N750
C28	110060	CAP	ELECT	50	MFD	25 V		SPRAGUE	TE1209
C29	110060	CAP	ELECT	50	MFD	25 V		SPRAGUE	TE1209
C30	110062	CAP	ELECT	500	MFD	50 V		SPRAGUE	39D507G050L4
C31	110062	CAP	ELECT	500	MFD	50 V		SPRAGUE	39D507G050L4
C32	110061	CAP	ELECT	100	MFD	50 V		SPRAGUE	39D107G050EJ4
C33	110061	CAP	ELECT	100	MFD	50 V		SPRAGUE	39D107G050EJ4
C34	121090	CAP	MYLAR	.015	MFD	100 V	10%	CDE	WMF1S15
C35	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F
C36	100017	CAP	CERAM	.01	MFD	200 V	10%	SPRAGUE	TH-S10
C37	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F
C38	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F
C39	101174	CAP	CERAM	.001	MFD	500 V	10%	AEROVOX	SCD3X5F

PARTS LIST

ASSEMBLY 402940 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION						
C40	101174	CAP	CERAM	.001 MFD 500 V		10%	AEROVOX	SCD3X5F
C41	101175	CAP	CERAM	220 PFD 500 V		10%	AEROVOX	SCD1X5F
CR01	211083	DIODE	SILICO	018			DANA	211083
CR02	211083	DIODE	SILICO	018			DANA	211083
CR03	221177	DIODE	SILICO	ZENER		1/4 W	MOTOROLA	M.2.4A25
CR04	221177	DIODE	SILICO	ZENER		1/4 W	MOTOROLA	M.2.4A25
CR05	211083	DIODE	SILICO	018			DANA	211083
CR06	211083	DIODE	SILICO	018			DANA	211083
CR07	211083	DIODE	SILICO	018			DANA	211083
CR08	211083	DIODE	SILICO	018			DANA	211083
CR09	211083	DIODE	SILICO	018			DANA	211083
CR10	211083	DIODE	SILICO	018			DANA	211083
CR11	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR12	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR13	211083	DIODE	SILICO	018			DANA	211083
CR14	220012	DIODE	SILICO	ZENER	1N958B		MOTOROLA	1N958B
CR15	220011	DIODE	SILICO	ZENER	1N968A		MOTOROLA	1N968A
CR16	220031	DIODE	SILICO	ZENER	1/4M3.3AZ5		MOTOROLA	1/4M3.3AZ5
CR17	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR18	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR19	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR20	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR21	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR22	220011	DIODE	SILICO	ZENER	1N968A		MOTOROLA	1N968A
CR23	220011	DIODE	SILICO	ZENER	1N968A		MOTOROLA	1N968A
CR24	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR25	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR26	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR27	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR28	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR29	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR30	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR31	210004	DIODE	SILICO	SD4			DIODES IN SD4	
CR32	210004	DIODE	SILICO	SD4			DIODES IN SD4	
L01	400315	CHOKE ASSY					AZTEC	10438
L02	400324	OUTPUT CHOKE ASSEMBLY					DANA	400324
L03	310033	CHOKE		100 MH			MILLER	9210-76

PARTS LIST

ASSEMBLY 402940 - Model 2820

REF. DESIG.	PART NO.	DESCRIPTION						
L04	310033	CHOKE		100 MH			MILLER	9210-76
L05	310033	CHOKE		100 MH			MILLER	9210-76
Q01	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q02	402717	ASSY		FSV 2820		V2	DANA	402717
Q03	200022	TRANS SILICO PNP		012			DANA	200022
Q04	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q05	201285	TRANS DUAL NPN		016S			DANA	201285
Q06	200078	TRANS SILICO NPN		FSV			DANA	200078
Q07	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q08	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q09	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q10	200035	TRANS SILICO NPN		014			DANA	200035
Q11	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q12	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q13	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q14	200011	TRANS SILICO PNP		009			DANA	200011
Q15	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q16	200022	TRANS SILICO PNP		012			DANA	200022
Q17	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q18	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q19	200035	TRANS SILICO NPN		014			DANA	200035
Q20	200035	TRANS SILICO NPN		014			DANA	200035
Q21	200035	TRANS SILICO NPN		014			DANA	200035
Q22	200011	TRANS SILICO PNP		009			DANA	200011
Q23	200011	TRANS SILICO PNP		009			DANA	200011
Q24	200035	TRANS SILICO NPN		014			DANA	200035
Q25	200011	TRANS SILICO PNP		009			DANA	200011
R01	020106	RES WW	100	OHM	.3%	1/8 W	CF ELEC	CF-4012
R02	000392	RES CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R03	010111	RES METAL	1	MEG	1%		CORNING	RN65C1004F
R04	020106	RES WW	.100	OHM	.3%	1/8 W	CF ELEC	CF-4012
R05	000392	RES CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R06	010111	RES METAL	1	MEG	1%		CORNING	RN65C1004F
R07	402717	ASSY		FSV 2820		V2	DANA	402717
R08	020097	RES WW	10	K	.1%	1/8 W	JORDAN	J-11
R09	020097	RES WW	10	K	.1%	1/8 W	JORDAN	J-11
R10	040093	RES VARI	500	OHM			SPECTRO	50-3-1-501
R100	030003	RES WW	39	OHM	2W	1/8 W	JORDAN	J-11
R101	001682	RES CARBON	1.5	K	5%	1/2 W	OHMITE	RC20GF152J

PARTS LIST

ASSEMBLY 402940 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
R102	001682	RES	CARBON	1.5 K	5%	1/2 W		OHMITE	RC20GF152J
R103	000151	RES	CARBON	150 OHM	5%	1/4 W		OHMITE	RC07GF151J
R104	020106	RES	WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R105	020106	RES	WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R106	000101	RES	CARBON	100 OHM	5%	1/4 W		OHMITE	RC07GF101J
R11	000621	RES	CARBON	620 OHM	5%	1/4 W		OHMITE	RC07GF621J
R12	000152	RES	CARBON	1.5 K	5%	1/4 W		OHMITE	RC07GF152J
R13	000242	RES	CARBON	2.4 K	5%	1/4 W		OHMITE	RC07GF242J
R14	000472	RES	CARBON	4.7 K	5%	1/4 W		OHMITE	RC07GF472J
R15	020424	RES	WW	9.179 K	.05%			JORDAN	J11
R16	020423	RES	WW	3.442 K	.05%			JORDAN	J11
R17	020422	RES	WW	1.530 K	.05%			JORDAN	J11
R18	020421	RES	WW	573.7 OHM	.05%			JORDAN	J11
R19	020420	RES	WW	281 OHM	.05%			CF	M18
R20	402717	ASSY			FSV 2820	V2		DANA	402717
R21	020086	RES	WW	840 OHM	.1%	1/8 W		KELVIN	EP-20
R22	402717	ASSY			FSV 2820	V2		DANA	402717
R23	020079	RES	WW	100 K	.1%	1/8 W		JORDAN	J-11
R24	402717	ASSY			FSV 2820	V2		DANA	402717
R25	402717	ASSY			FSV 2820	V2		DANA	402717
R26	020079	RES	WW	100 K	.1%	1/8 W		JORDAN	J-11
R27	402717	ASSY			FSV 2820	V2		DANA	402717
R28	040092	RES	VARI	20 K				SPECTRO	50-3-1-203
R29	040092	RES	VARI	20 K				SPECTRO	50-3-1-203
R30	011178	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN20X4994F
R31	011178	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN20X4994F
R32	010130	RES	METAL	6.19 K	1%	1/4 W		ELECTRA	RN60D6191F
R33	402717	ASSY			FSV 2820	V2		DANA	402717
R34	010059	RES	METAL	20 K	1%	1/4 W		ELECTRA	RN60D2002F
R35	010059	RES	METAL	20 K	1%	1/4 W		ELECTRA	RN60D2002F
R36	010110	RES	METAL	10 K	1%	1/2 W		ELECTRA	RN65C1002F
R37	040093	RES	VARI	500 OHM				SPECTRO	50-3-1-501
R38	402717	ASSY			FSV 2820	V2		DANA	402717
R39	402717	ASSY			FSV 2820	V2		DANA	402717
R40	020078	RES	WW	50 K	.1%	1/8 W		JORDAN	J-11
R41	020078	RES	WW	50 K	.1%	1/8 W		JORDAN	J-11
R42	020425	RES	WW	10.455 K	.1%			CF	M20
R43	040108	RES	VARI	50 OHM				SPECTROL	50-3
R44	020425	RES	WW	10.455 K	.1%			CF	M20

PARTS LIST

ASSEMBLY 402940 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
R45	402717	ASSY			FSV 2820	V2		DANA	402717
R46	040020	RES	VARI	1 K	10%	1/4 W		BOURNS	271-1-102-
R47	402717	ASSY			FSV 2820	V2		DANA	402717
R48	402717	ASSY			FSV 2820	V2		DANA	402717
R49	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R50	020104	RES	WW	3.75 K	1%	1/8 W		CF ELEC	CF3133
R51	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R52	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R53	000512	RES	CARBON	5.1 K	5%	1/4 W		OHMITE	RC07GF512J
R54	000153	RES	CARBON	15 K	5%	1/4 W		OHMITE	RC07GF153J
R55	000752	RES	CARBON	7.5 K	5%	1/4 W		OHMITE	RC07GF752J
R56	000123	RES	CARBON	12 K	5%	1/4 W		OHMITE	RC07GF123J
R57	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R58	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R59	000104	RES	CARBON	100 K	5%	1/4 W		OHMITE	RC07GF104J
R60	010019	RES	METAL	30.1 K	1%	1/4 W		ELECTRA	RN60B3012F
R61	000153	RES	CARBON	15 K	5%	1/4 W		OHMITE	RC07GF153J
R62	011334	RES	METAL	2.61 K	1%	1/4 W		ELECTRA	RN60D2611F
R63	010008	RES	METAL	1.4 K	1%	1/4 W		IRC	RN60D142F
R64	000103	RES	CARBON	10 K	5%	1/4 W		OHMITE	RC07GF103J
R65	000103	RES	CARBON	10 K	5%	1/4 W		OHMITE	RC07GF103J
R66	000221	RES	CARBON	220 OHM	5%	1/4 W		OHMITE	RC07GF221J
R67	010027	RES	METAL	499 OHM	1%	1/4 W		ELECTRA	RN60D4990F
R68	000123	RES	CARBON	12 K	5%	1/4 W		OHMITE	RC07GF123J
R69	000103	RES	CARBON	10 K	5%	1/4 W		OHMITE	RC07GF103J
R70	000204	RES	CARBON	200 K	5%	1/4 W		OHMITE	RC07GF204J
R71	000221	RES	CARBON	220 OHM	5%	1/4 W		OHMITE	RC07GF221J
R72	000823	RES	CARBON	82 K	5%	1/4 W		OHMITE	RC07GF823J
R73	000222	RES	CARBON	2.2 K	5%	1/4 W		OHMITE	RC07GF222J
R74	000153	RES	CARBON	15 K	5%	1/4 W		OHMITE	RC07GF153J
R75	000152	RES	CARBON	1.5 K	5%	1/4 W		OHMITE	RC07GF152J
R76	020119	RES	WW	680 OHM	1%	1/2 W		CF ELEC	M-20
R77	000123	RES	CARBON	12 K	5%	1/4 W		OHMITE	RC07GF123J
R78	000183	RES	CARBON	18 K	5%	1/4 W		OHMITE	RC07GF183J
R79	000622	RES	CARBON	6.2 K	5%	1/4 W		OHMITE	RC07GF622J
R80	000113	RES	CARBON	11 K	5%	1/4 W		OHMITE	RC07GF113J
R81	000223	RES	CARBON	22 K	5%	1/4 W		OHMITE	RC07GF223J

PARTS LIST

ASSEMBLY 402940 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
R82	000622	RES	CARBON	6.2	K	5%	1/4 W	OHMITE	RC07GF622J
R83	000682	RES	CARBON	6.8	K	5%	1/4 W	OHMITE	RC07GF682J
R84	000392	RES	CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R85	000241	RES	CARBON	240	OHM	5%	1/4 W	OHMITE	RC07GF241J
R86	001469	RES	CARBON	1.2	K	5%	1/2 W	OHMITE	RC20GF122J
R87	000124	RES	CARBON	120	K	5%	1/4 W	OHMITE	RC07GF124J
R88	001740	RES	CARBON	6.2	OHM	5%	1/2 W	OHMITE	RC20GF060J
R89	001741	RES	CARBON	9.1	OHM	5%	1/2 W	OHMITE	RC20GF090J
R90	001738	RES	CARBON	1.5	OHM	5%	1/2 W	OHMITE	RC20GF010J
R91	041476	RES	VARI	100	OHM	10%	1/4 W	CTS	BK24376
R92	041476	RES	VARI	100	OHM	10%	1/4 W	CTS	BK24376
R93	001739	RES	CARBON	4.3	OHM	5%	1/2 W	OHMITE	RC20GF040J
R94	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R95	000392	RES	CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R96	000392	RES	CARBON	0003.9	K	5%	1/4 W	OHMITE	RC07GF392J
R97	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R98	000100	RES	CARBON	10	OHM	5%	1/4 W	OHMITE	RC07GF100J
R99	030003	RES	WW	39	OHM	2W	1/8 W	JORDAN	J-11
T01	300021	TRANSFORMER						AZTEC 6242	

PARTS LIST

ASSEMBLY 403056 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION						
C01	121092	CAP	MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22
C02	121092	CAP	MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22
C03	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C04		NOT USED						
C05		NOT USED						
C06		NOT USED						
C07	121093	CAP	MYLAR	.047 MFD	100 V	10%	CDE	WMF1S47
C08	121091	CAP	MYLAR	.033 MFD	100 V	10%	CDE	WMF1533
C09	121090	CAP	MYLAR	.015 MFD	100 V	10%	CDE	WMF1S15
C10	121088	CAP	MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1
C11	121088	CAP	MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1
C12	101145	CAP	CERAM	100 PFD	500 V	10%	AEROVOX	SCD1X5F
C13	101145	CAP	CERAM	100 PFD	500 V	10%	AEROVOX	SCD1X5F
C14	101641	CAP	CERAM	470 PFD	500 V	10%	AEROVOX	SCD1X5F
C15	130004	CAP	CERAM	2-8 PFD	500 V	10%	ERIE	538-00289R
C16		NOT USED						
C17	100009	CAP	CERAM	5 PFD	500 V	10%	AEROVOX	TCD-N750
C18	121088	CAP	MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1
C19	111262	CAP	ELECT	10 MFD	25 V	20%	SPRAGUE	TE1204
C20	121091	CAP	MYLAR	.033 MFD	100 V	10%	CDE	WMF1533
C21	101641	CAP	CERAM	470 PFD	500 V	10%	AEROVOX	SCD1X5F
C22	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C23	101182	CAP	CERAM	47 PFD	500 V	10%	AEROVOX	TCD-N750
C24	101641	CAP	CERAM	470 PFD	500 V	10%	AEROVOX	SCD1X5F
C25	121468	CAP	MYLAR	.022 MFD	100 V	10%	CDE	WMF1S22
C26	101182	CAP	CERAM	47 PFD	500 V	10%	AEROVOX	TCD-N750
C27	101182	CAP	CERAM	47 PFD	500 V	10%	AEROVOX	TCD-N750
C28	110060	CAP	ELECT	50 MFD	25 V		SPRAGUE	TE1209
C29	110060	CAP	ELECT	50 MFD	25 V		SPRAGUE	TE1209
C30	110062	CAP	ELECT	500 MFD	50 V		SPRAGUE	39D507G050L4
C31	110062	CAP	ELECT	500 MFD	50 V		SPRAGUE	39D507G050L4
C32	110061	CAP	ELECT	100 MFD	50 V		SPRAGUE	39D107G050EJ4
C33	110061	CAP	ELECT	100 MFD	50 V		SPRAGUE	39D107G050EJ4
C34	121090	CAP	MYLAR	.015 MFD	100 V	10%	CDE	WMF1S15
C35	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C36	100017	CAP	CERAM	.01 MFD	200 V	10%	SPRAGUE	TH-S10
C37	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C38	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F
C39	101174	CAP	CERAM	.001 MFD	500 V	10%	AEROVOX	SCD3X5F

PARTS LIST

ASSEMBLY 403056 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION	
C40	101174	CAP CERAM .001 MFD 500 V 10%	AEROVOX SCD3X5F
C41	101175	CAP CERAM 220 PFD 500 V 10%	AEROVOX SCD1X5F
CR01	211083	DIODE SILICO 018	DANA 211083
CR02	211083	DIODE SILICO 018	DANA 211083
CR03	220030	DIODE SILICO ZENER 1/4M2.4AZ5	MOTOROLA 1/4M2.4AZ5
CR04	220030	DIODE SILICO ZENER 1/4M2.4AZ5	MOTOROLA 1/4M2.4AZ5
CR05	211083	DIODE SILICO 018	DANA 211083
CR06	211083	DIODE SILICO 018	DANA 211083
CR07	211083	DIODE SILICO 018	DANA 211083
CR08	211083	DIODE SILICO 018	DANA 211083
CR09	211083	DIODE SILICO 018	DANA 211083
CR10	211083	DIODE SILICO 018	DANA 211083
CR11	210004	DIODE SILICO SD4	DIODES IN SD4
CR12	210004	DIODE SILICO SD4	DIODES IN SD4
CR13	211083	DIODE SILICO 018	DANA 211083
CR14	220012	DIODE SILICO ZENER 1N958B	MOTOROLA 1N958B
CR15	220011	DIODE SILICO ZENER 1N968A	MOTOROLA 1N968A
CR16	220031	DIODE SILICO ZENER 1/4M3.3AZ5	MOTOROLA 1/4M3.3AZ5
CR17	210004	DIODE SILICO SD4	DIODES IN SD4
CR18	210004	DIODE SILICO SD4	DIODES IN SD4
CR19	210004	DIODE SILICO SD4	DIODES IN SD4
CR20	210004	DIODE SILICO SD4	DIODES IN SD4
CR21	210004	DIODE SILICO SD4	DIODES IN SD4
CR22	220011	DIODE SILICO ZENER 1N968A	MOTOROLA 1N968A
CR23	220011	DIODE SILICO ZENER 1N968A	MOTOROLA 1N968A
CR24	210004	DIODE SILICO SD4	DIODES IN SD4
CR25	210004	DIODE SILICO SD4	DIODES IN SD4
CR26	210004	DIODE SILICO SD4	DIODES IN SD4
CR27	210004	DIODE SILICO SD4	DIODES IN SD4
CR28	210004	DIODE SILICO SD4	DIODES IN SD4
CR29	210004	DIODE SILICO SD4	DIODES IN SD4
CR30	210004	DIODE SILICO SD4	DIODES IN SD4
CR31	210004	DIODE SILICO SD4	DIODES IN SD4
CR32	210004	DIODE SILICO SD4	DIODES IN SD4
L01	400315	CHOKE ASSY	AZTEC 10438
L02	400324	OUTPUT CHOKE ASSEMBLY	DANA 400324
L03	310033	CHOKE 100 MH	MILLER 9210-76

PARTS LIST

ASSEMBLY 403056 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION						
L04	310033	CHOKE		100 MH			MILLER	9210-76
L05	310033	CHOKE		100 MH			MILLER	9210-76
Q01	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q02	403072	ASSY		FSV				
Q03	200022	TRANS SILICO PNP		012			DANA	200022
Q04	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q05	201285	TRANS DUAL NPN		016S			DANA	201285
Q06	200078	TRANS SILICO NPN		FSV			DANA	200078
Q07	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q08	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q09	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q10	200035	TRANS SILICO NPN		014			DANA	200035
Q11	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q12	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q13	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q14	200011	TRANS SILICO PNP		009			DANA	200011
Q15	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q16	200022	TRANS SILICO PNP		012			DANA	200022
Q17	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q18	200043	TRANS SILICO NPN		2N3565			FAIRCHILD	2N3565
Q19	200035	TRANS SILICO NPN		014			DANA	200035
Q20	200035	TRANS SILICO NPN		014			DANA	200035
Q21	200035	TRANS SILICO NPN		014			DANA	200035
Q22	200011	TRANS SILICO PNP		009			DANA	200011
Q23	200011	TRANS SILICO PNP		009			DANA	200011
Q24	200035	TRANS SILICO NPN		014			DANA	200035
Q25	200011	TRANS SILICO PNP		009			DANA	200011
R01	020106	RES WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R02	000392	RES CARBON	0003.9 K	5%	1/4 W		OHMITE	RC07GF392J
R03		NOT USED						
R04	020106	RES WW	.100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R05	000392	RES CARBON	0003.9 K	5%	1/4 W		OHMITE	RC07GF392J
R06		NOT USED						
R07		NOT USED						
R08		NOT USED						
R09		NOT USED						
R10	020503	RES WW	55.18 OHM	.1%			JORDAN	M-18
R100	030003	RES WW	39 OHM	2W	1/8 W		JORDAN	J-11
R101	001682	RES CARBON	1.5 K	5%	1/2 W		OHMITE	RC20GF152J

PARTS LIST

ASSEMBLY 4C3056 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
R102	C01682	RES	CARBON	1.5 K	5%	1/2 W		OHMITE	RC20GF152J
R103	C00151	RES	CARBON	150 OHM	5%	1/4 W		OHMITE	RC07GF151J
R104	C20106	RES	WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R105	020106	RES	WW	100 OHM	.3%	1/8 W		CF ELEC	CF-4012
R106	C00101	RES	CARBON	100 OHM	5%	1/4 W		OHMITE	RC07GF101J
R11	CCC102	RES	CARBON	1 K	5%	1/4 W		OHMITE	RC07GF102J
R12	CCC152	RES	CARBON	1.5 K	5%	1/4 W		OHMITE	RC07GF152J
R13	CCC242	RES	CARBON	2.4 K	5%	1/4 W		OHMITE	RC07GF242J
R14	CCC472	RES	CARBON	4.7 K	5%	1/4 W		OHMITE	RC07GF472J
R15	020423	RES	WW	3.442 K	.05%			JORDAN	J11
R16	020422	RES	WW	1.530 K	.05%			JORDAN	J11
R17	020421	RES	WW	573.7 OHM	.05%			JORDAN	J11
R18	020420	RES	WW	281 OHM	.05%			CF	M18
R19	020368	RES	WW	139 OHM	.1%			JORDAN	M-18
R20	403072	ASSY		FSV					
R21	020086	RES	WW	840 OHM	.1%	1/8 W		KELVIN	EP-20
R22	403072	ASSY		FSV					
R23	020079	RES	WW	100 K	.1%	1/8 W		JORDAN	J-11
R24	403072	ASSY		FSV					
R25	403072	ASSY		FSV					
R26	020079	RES	WW	100 K	.1%	1/8 W		JORDAN	J-11
R27	403072	ASSY		FSV					
R28	040092	RES	VARI	20 K				SPECTRO	50-3-1-203
R29	040092	RES	VARI	20 K				SPECTRO	50-3-1-203
R30	011178	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN20X4994F
R31	011178	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN20X4994F
R32	010130	RES	METAL	6.19 K	1%	1/4 W		ELECTRA	RN60D6191F
	403072	ASSY		FSV					
R34	010059	RES	METAL	20 K	1%	1/4 W		ELECTRA	RN60D2002F
R35	010059	RES	METAL	20 K	1%	1/4 W		ELECTRA	RN60D2002F
R36	010110	RES	METAL	10 K	1%	1/2 W		ELECTRA	RN65C1002F
R37	040093	RES	VARI	500 OHM				SPECTRO	50-3-1-501
R38	403072	ASSY		FSV					
R39	403072	ASSY		FSV					
R40	020078	RES	WW	50 K	.1%	1/8 W		JORDAN	J-11
R41	020078	RES	WW	50 K	.1%	1/8 W		JORDAN	J-11
R42	020425	RES	WW	10.455 K	.1%			CF	M20
R43	040108	RES	VARI	50 OHM				SPECTROL	50-3
R44	020425	RES	WW	10.455 K	.1%			CF	M20

PARTS LIST

ASSEMBLY 403056 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION							
R45	403072	ASSY		FSV					
R46	040020	RES	VARI	1	K	10%	1/4 W	BOURNS	271-1-102-
R47	403072	ASSY		FSV					
R48	403072	ASSY		FSV					
R49	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F
R50	020104	RES	WW	3.75	K	1%	1/8 W	CF ELEC	CF3133
R51	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F
R52	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F
R53	000512	RES	CARBON	5.1	K	5%	1/4 W	OHMITE	RC07GF512J
R54	000153	RES	CARBON	15	K	5%	1/4 W	OHMITE	RC07GF153J
R55	000752	RES	CARBON	7.5	K	5%	1/4 W	OHMITE	RC07GF752J
R56	000123	RES	CARBON	12	K	5%	1/4 W	OHMITE	RC07GF123J
R57	000393	RES	CARBON	39	K	5%	1/4 W	OHMITE	RC07GF393J
R58	000393	RES	CARBON	39	K	5%	1/4 W	OHMITE	RC07GF393J
R59	000104	RES	CARBON	100	K	5%	1/4 W	OHMITE	RC07GF104J
R60	010019	RES	METAL	30.1	K	1%	1/4 W	ELECTRA	RN60B3012F
R61	000153	RES	CARBON	15	K	5%	1/4 W	OHMITE	RC07GF153J
R62	011334	RES	METAL	2.61	K	1%	1/4 W	ELECTRA	RN60D2611F
R63	010008	RES	METAL	1.4	K	1%	1/4 W	IRC	RN60D142F
R64	000103	RES	CARBON	10	K	5%	1/4 W	OHMITE	RC07GF103J
R65	000103	RES	CARBON	10	K	5%	1/4 W	OHMITE	RC07GF103J
R66	000221	RES	CARBON	220	OHM	5%	1/4 W	OHMITE	RC07GF221J
R67	010027	RES	METAL	499	OHM	1%	1/4 W	ELECTRA	RN60D4990F
R68	000123	RES	CARBON	12	K	5%	1/4 W	OHMITE	RC07GF123J
R69	000103	RES	CARBON	10	K	5%	1/4 W	OHMITE	RC07GF103J
R70	000204	RES	CARBON	200	K	5%	1/4 W	OHMITE	RC07GF204J
R71	000221	RES	CARBON	220	OHM	5%	1/4 W	OHMITE	RC07GF221J
R72	000823	RES	CARBON	82	K	5%	1/4 W	OHMITE	RC07GF823J
R73	000222	RES	CARBON	2.2	K	5%	1/4 W	OHMITE	RC07GF222J
R74	000153	RES	CARBON	15	K	5%	1/4 W	OHMITE	RC07GF153J
R75	000152	RES	CARBON	1.5	K	5%	1/4 W	OHMITE	RC07GF152J
R76	020119	RES	WW	680	OHM	1%	1/2 W	CF ELEC	M-20
R77	000123	RES	CARBON	12	K	5%	1/4 W	OHMITE	RC07GF123J
R78	000183	RES	CARBON	18	K	5%	1/4 W	OHMITE	RC07GF183J
R79	000622	RES	CARBON	6.2	K	5%	1/4 W	OHMITE	RC07GF622J
R80	000113	RES	CARBON	11	K	5%	1/4 W	OHMITE	RC07GF113J
R81	000223	RES	CARBON	22	K	5%	1/4 W	OHMITE	RC07GF223J

PARTS LIST

ASSEMBLY 403056 - Model 2820

A

REF. DESIG.	PART NO.	DESCRIPTION								
R82	000622	RES	CARBON	6.2	K	5%	1/4	W	OHMITE	RC07GF622J
R83	000682	RES	CARBON	6.8	K	5%	1/4	W	OHMITE	RC07GF682J
R84	000392	RES	CARBON	0003.9	K	5%	1/4	W	OHMITE	RC07GF392J
R85	000241	RES	CARBON	240	OHM	5%	1/4	W	OHMITE	RC07GF241J
R86	001469	RES	CARBON	1.2	K	5%	1/2	W	OHMITE	RC20GF122J
R87	000124	RES	CARBON	120	K	5%	1/4	W	OHMITE	RC07GF124J
R88	001740	RES	CARBON	6.2	OHM	5%	1/2	W	OHMITE	RC20GF060J
R89	001741	RES	CARBON	9.1	OHM	5%	1/2	W	OHMITE	RC20GF090J
R90	001738	RES	CARBON	1.5	OHM	5%	1/2	W	OHMITE	RC20GF010J
R91	041476	RES	VARI	100	OHM	10%	1/4	W	CTS	BK24376
R92	041476	RES	VARI	100	OHM	10%	1/4	W	CTS	BK24376
R93	001739	RES	CARBON	4.3	OHM	5%	1/2	W	OHMITE	RC20GF040J
R94	000100	RES	CARBON	10	OHM	5%	1/4	W	OHMITE	RC07GF100J
R95	000392	RES	CARBON	0003.9	K	5%	1/4	W	OHMITE	RC07GF392J
R96	000392	RES	CARBON	0003.9	K	5%	1/4	W	OHMITE	RC07GF392J
R97	000100	RES	CARBON	10	OHM	5%	1/4	W	OHMITE	RC07GF100J
R98	000100	RES	CARBON	10	OHM	5%	1/4	W	OHMITE	RC07GF100J
R99	030003	RES	WW	39	OHM	2W	1/8	W	JORDAN	J-11
T01	300021	TRANSFORMER							AZTEC	6242

DANA®

MP MASTER
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